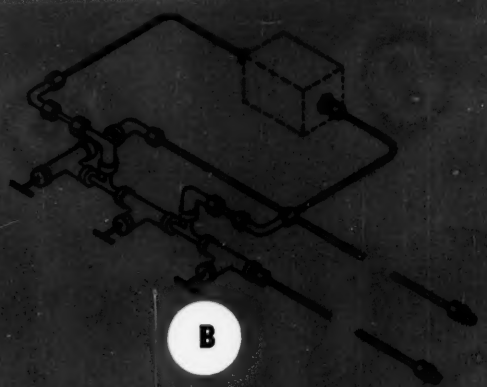
INSTRUMENTS and AUTOMATION

Including: Instrument Manufacturing • The Journal of the SCMA • Simulation Council Newsletter



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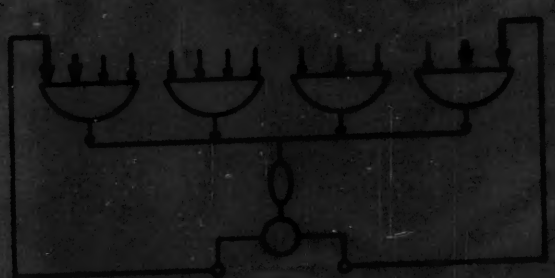

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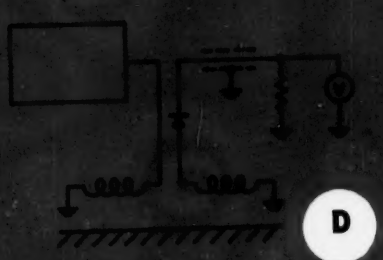

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D Vibration measurement can involve three variables—displacement, velocity, and acceleration ..... page 470

MARCH 1957

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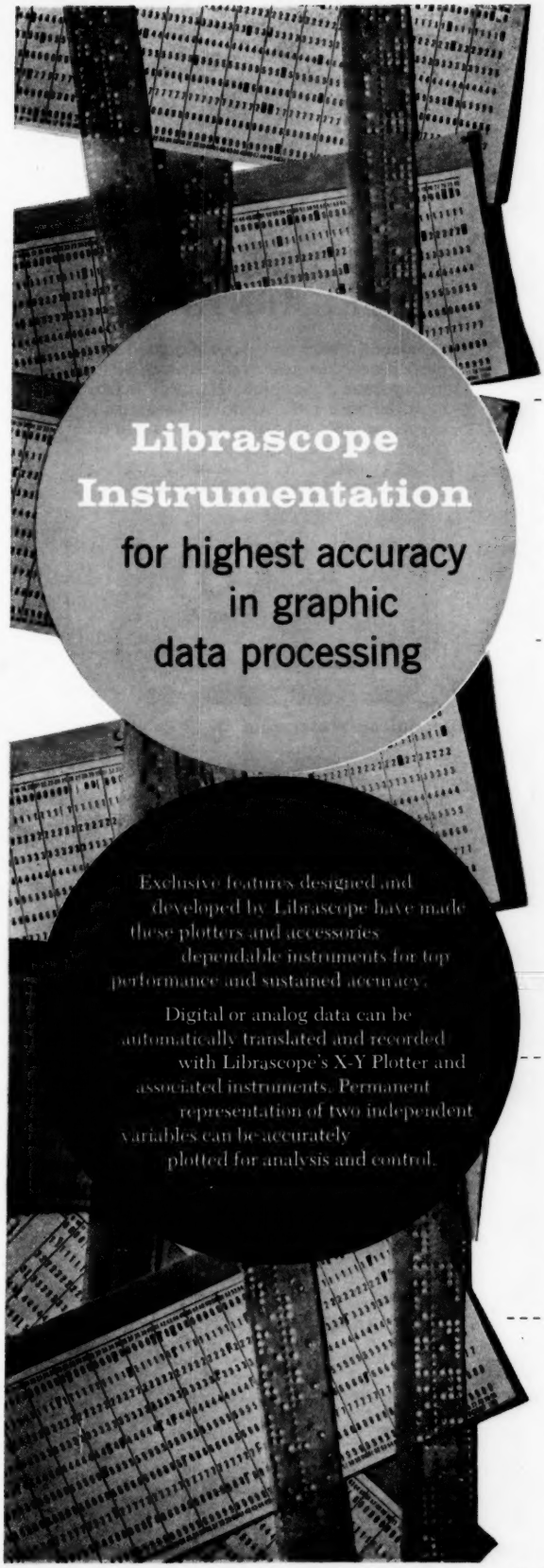

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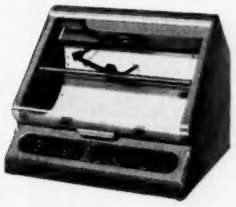

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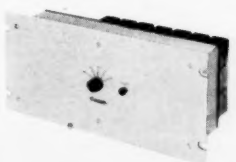

LIBRASCOPE BINARY CONVERTER, MODEL 252 consists of two banks of relays and precision resistors simulating a precision potentiometer. The resistors weight the relays in straight binary so that each bank serves as an input to one axis of the XY plotter. Total resistance is 10,000 ohms per bank. Relays within the converter control the plot cycle.

Mounting: Standard RCA, RMA rack mounts.

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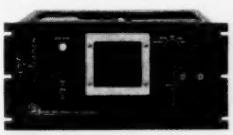
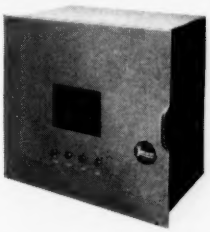
Mounting: Standard RCA or RMA rack mounts or in case.





LIBRASCOPE PUNCHED TAPE CONVERTER operates from punched tape reader. Can be modified to operate with any digital computers furnishing a punched tape output. If printed listing desired, unit may be operated from tape-actuated typewriter, such as the Flexowriter. Programming need not be specified on tape. Sequence operation. A particular tape may be programmed to accommodate various tape formats.

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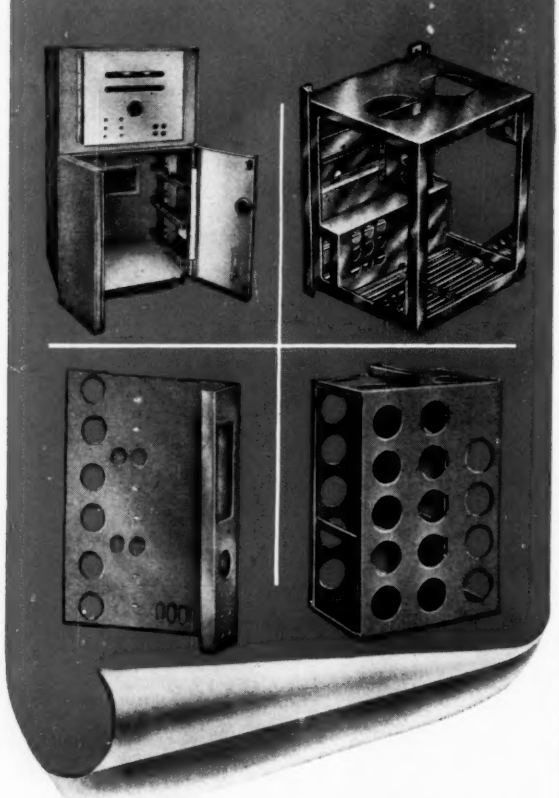

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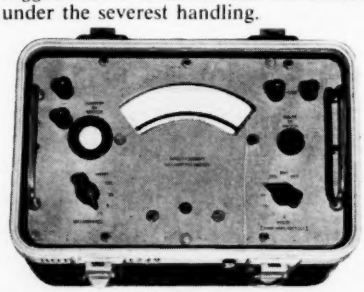

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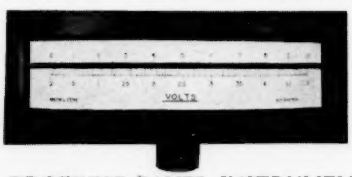

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March 1957

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THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

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Letters to the editor

Editor, I&A:

I wish to commend your penetrating analysis of the actual and presumed effects of Automation [The Effect of Automation on Productivity —November issue].

Would that your article were more widely circulated.

Henry R. Selden
Avon, New York

Editor, I&A:

So a computer is a giant "brain". Ha.

The finest of digital computers can do anything that can be done by a two fingered idiot, counting on his fingers, who can follow a sequence of instructions. Only difference: the mechanical idiot can do it faster.

Anyway, who does not know the difference between "thinking" and computing. Any bonehead or boob can compute. However, for thinking you have to use qualities such as judgment, intelligence, intuition, evaluation of evidence or information, and a lot of other things not included in a non-thinking, non-knowing, noncaring, unintelligent mess of electrical circuits and machinery.

A computer is a machine, is a machine, is a machine. It doesn't know, and it doesn't care.

W. H. Sayler
Specialty Sales Co.

We do not remember having called a computer a giant brain. In fact two recent quotes (Dr. William Schart and Dr. John Cell) in the *Simulation Council Newsletter* call them morons. However, judgment (decision-making) and evaluation of evidence or information are strong points of computers, and if we define intelligence and intuition we might be able to show that computers exhibit these qualities also. As Mr. Sayler points out, the computer is a fast, reliable, unemotional servant.

Editor, I&A:

Instruments and Automation is widely read by our personnel and we would like to compliment you on the outstanding job you are doing.

John F. Bishop
Scientific Instruments, Division
Beckman Instruments, Inc.

Editor, I&A:

Enclosed please find your survey card (sampling the economic condition of instrument manufacturers). I would like to supplement your modest request with a few observations.

A. In the instrument mfg. business it takes about $10,000 investment per productive employee. This means that small business in the eyes of the government is a $5,000,000 or less business.

B. In the same business it takes about $10,000 of orders to employ one productive employee for one year. Again a rough check on comment A.

Businesses over $500,000 should be considered "big business."

C. Most businesses over $500,000 gross/yr. do not buy instruments assembled in a final piece of equipment—if they can avoid it—for the following reasons:

(1) Purchases over $100 must be capitalized.

(2) If the parts are bought and engineers or lab assistants diverted to construction work on instrumentation, the cost need not be capitalized, but even better can be written off as an overhead expense.

(3) Engineers do not push fairly evaluated budget requests (probably because they have to go thru the same hands for approval that process their wage increases and other requests).

(4) Engineers are too willing to demonstrate that they know where and how to buy parts for plant instrumentation and try to save the company money. The P. A. suffers because instead of buying just one instrument or one system, he has to buy 100 or more parts from a dozen or more sources. The P.A. cannot do much about it. The engineer can think of plenty of reasons why he needs his own version and no other will do.

I have worked for about six companies in 25 years. Some were undercapitalized and it was a matter of necessity to produce your own facilities even to the point of neglecting the prime responsibility of your job (to design manufacturable products). Some were so large that tax avoidance and evasion was a factor in producing instrumentation, particularly

in the $50,000-and-up bracket. A short period with the government turned up the fact that a large number of civil service people think that business gets big profits from all government business: each and every civil-service employee feels it is his mission to make sure that no profit is allowed if possible. They also feel that it will be done better and cheaper if the work is not allowed to go out to industry at all.

Big business can refuse to bid government sealed bid contracts secure in the knowledge that many projects can be handled only by them. The projects so negotiated are usually so large that only the top echelon in procurement agencies will handle the matter and are thereby assured the best contacts in drawing up the terms of the contract. Small business has to deal with the poorest level of the procurement offices and, accordingly, these ill-advised worrywarts are so careful that they are gradually killing all small business which depends on some government work.

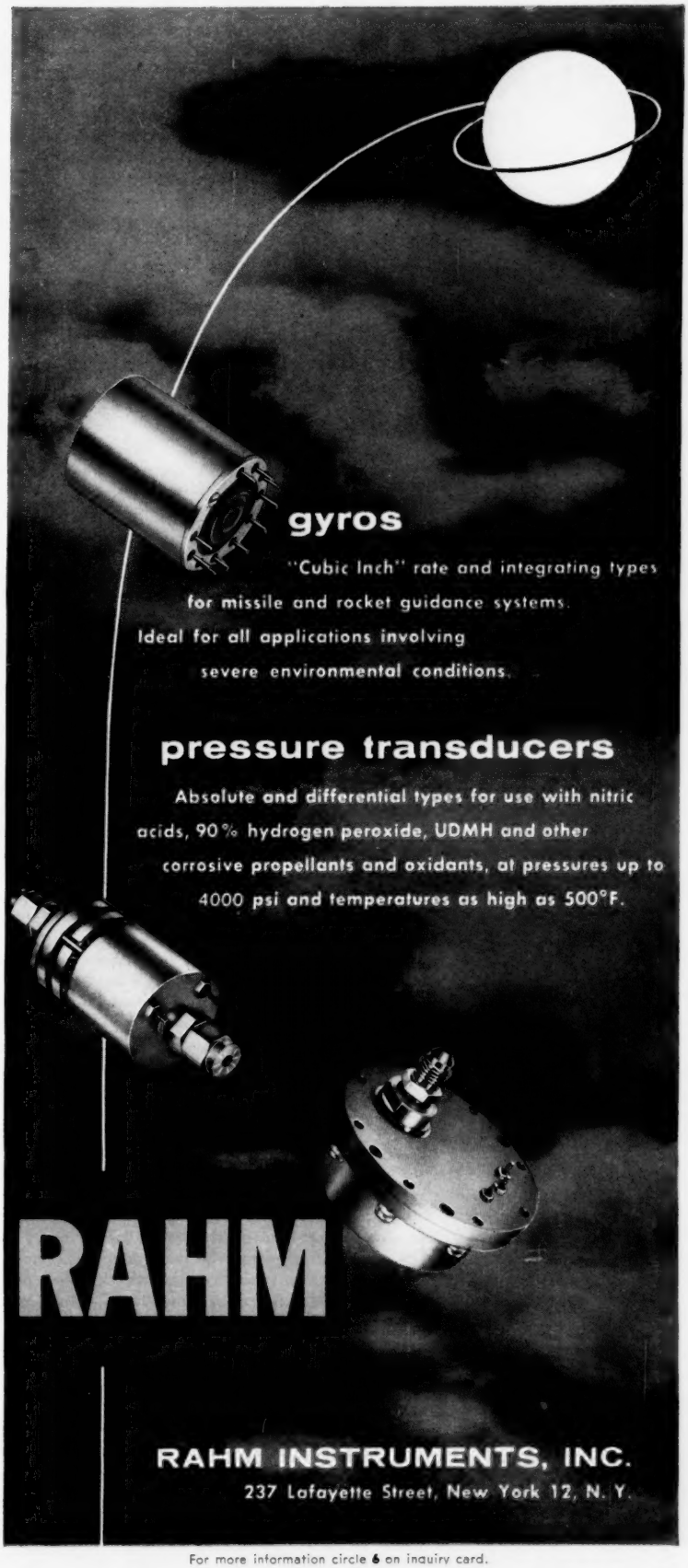
I have bid over $10,000,000 of government work in six years to get less than $250,000 worth of orders in the instrument field. The Small Business Office is totally useless to me. First, I have to be the low bidder—and if I am low what do I need them for? Only one application for financial assistance in thousands ever gets all the way thru the red tape. Nine out of ten jobs are bid less than the cost of the material plus labor at absolute minimum.

Subcontract work has even worse hazards than prime contracts.

It would be interesting to select a group of average size instrument companies and analyze how they showed increase in profit in the last few years. Some show paper profits to promote stock issues. Some buy smaller companies to expand their line and recover the money invested —and probably free engineering invested in worthwhile products that can't be put over with 100 cent dollars without help by tax dollars.

It would be just as interesting to find out why the ones that are losing are in trouble.

Our company carries on only by having sold a half interest in early 1955 and immediately investing the money in another company which was not engaged in instrument manufacturing but in a related group of items. Our peak was $150,000 for 1953-54 and we have equalled it since. We are again going to purchase another company and will thereby become almost exclusively a consulting and engineering group af-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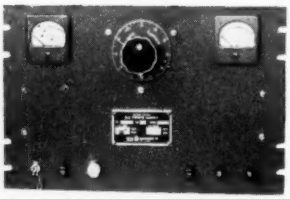

Model No. G45-5F

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Ripple: 1%

UNIT FOR RACK MOUNT. CAN BE SUPPLIED FOR BENCH

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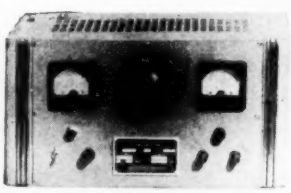

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CONTINUOUS RATINGS

Request Bulletin No. 10

GATES ELECTRONIC CO.

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TY 2-6490

For more information circle **7** on inquiry card.

ter transferring a few of our instruments as a side line for our subsidiaries. Maybe we too should claim an improved position in the instrument manufacturing field—but in all honesty this is not the case.

McGraw-Hill's Buyer Guide had twenty less pages of ads in 1956, which is the first time it hasn't increased since it was started. You will note it listed almost 15 pages of companies in 56 against 13¾ pages in 55. Some big-name advertisers were missing this year in advertising.

Chas E. Dennis
Pres. & Ch. Eng.
Pennsylvania Testing Laboratories, Inc.

This communication points out several important issues:

1. The tendency to build, rather than buy, instruments still exists—and still hurts, particularly the small business.

2. This tendency is encouraged by some tax laws, and by the innate instinct against ordering what appears to be "expensive" equipment that might be constructed more cheaply.

3. Small business is finding it tough to get profitable contracts from the government.

4. The Small Business Office of the Department of Commerce has failed small business.

5. The profits reported by some businesses are paper profits, not normal and healthy business profits.

With regard to items 1 and 2, we have for decades emphasized the inefficiency and poor economy of building instruments that are available commercially; we have preached continually that investment in proper instrumentation is essential to the work of every engineer, scientist or technical worker.

Items 3, 4, and 5 are matters for all citizens to ponder.

Editor, I&A:

Your editorial "Instrumentation—1956" (Feb., *I&A*) sums up quite succintly the primary developments of 1956, at least from the standpoint of our instrument industry. Your division of the areas of primary interest into the two groups of concepts and hardware is, I think, very good. I think your choice of the three most important concepts was also good, although I would question the statement that system engineering is a new concept. It certainly received more attention in 1956 than it has previously but, as you well know, system engineering has been around in theory, and to a more limited extent in practice, for a number of years.

Also in regard to the systems engineering observations, you ask the question as to who will gather the data on response characteristics of the various units. It seems from your write-up that the question revolves around who *should* obtain this data, rather than who is technically and theoretically able to obtain this data in the framework to which you refer.

I feel that your thesis that both optimal control and systems engineering are essentially analytical techniques is a good one, and one that should be better publicized and understood. There probably is a large segment in industry which is awaiting the development of additional equipment for control in systems engineering, when the actuality is that existing equipment would perform satisfactorily once a given process was thoroughly enough analyzed as to its requirements and essential features.

In your section on hardware, you refer to data processors which reached the acceptance stage in 1956. The Automation Show saw the introduction of a new low-cost data logger by Hanson-Gorrill-Brian, Inc. of Glen Cove, N. Y., which would also be of rather wide-spread importance in the field of data logging, particularly where smaller manufacturers and processors are involved. I personally feel that this low-cost unit (which will range in price between $5000 and $6000) will allow such an intermediate-sized user to acquaint himself with the benefits of data logging, and will thus educate him, so to speak, into the class of data processors, and will make him more receptive to new techniques in this field.

Howard W. Mattson
Bristol News Service
The Bristol Company

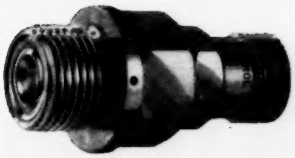
Editor, I&A:

Thank you very much indeed for your letter in which you gave us the name and address of the manufacturers of Bantam Centrifugal Pumps . . . . We are very impressed by your taking so much trouble in assisting us and should like to express once again our grateful appreciation.

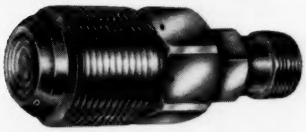
P. H. Kendall
Stanmore, Middx.
England

Correction

An error crept into the article "Short Methods for Calculating Fluid Flow" by Dale Kelly, which appeared in the January issue of INSTRUMENTS and AUTOMATION. On page 76 under "Correction Factors for Table 2" the sentence: "An error of 1% will result from a temperature change of 10% . . ." should have read "An error of 1% will result from a temperature change of 10F° . . . ."

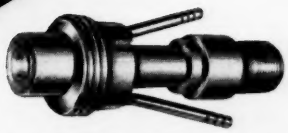


EPI ENGINE PRESSURE PICKUP. Highly accurate, versatile transducer for dynamic pressure measurements requiring high frequency response. Ranges from 0–100 up to 15,000 psi.



EPQ ENGINE PRESSURE PICKUP. For high pressure applications in blast analyses, gun barrel pressures, hydraulic high pressures, etc. Ranges up to 60,000 psi.

PRESSURE MEASUREMENT TO ITS FINEST POINT



ETY PRESSURE PICKUP. Water-cooled, high frequency transducer for pressure studies under very high temperatures. Can be exposed to gas temperatures above 5000°F without damage.

HIGH TEMPERATURE ADAPTER. For use with Norwood Controls EP Transducers where temperature of the pressure medium is between 250°F and 600°F. Suitable for pressures up to 10,000 psi.

NORWOOD CONTROLS catenary diaphragm pressure transducers have established new standards of reliability in pressure measurements in dynamic systems . . . gasoline and diesel engines . . . jet engines . . . rocket motors . . . high pressure, high temperature chemical reactions . . . hydraulic and pneumatic systems. Complete technical information upon request.

Copyright 1956 by Detroit Controls Corp.

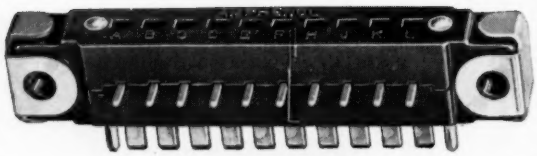
NC NORWOOD CONTROLS

HIGH reliability
LOW maintenance

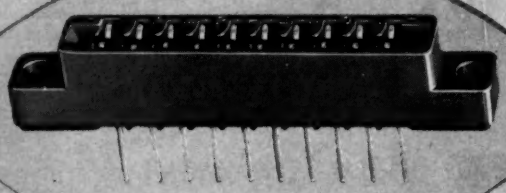
NORWOOD CONTROLS *UNIT OF DETROIT CONTROLS CORPORATION*
937 Washington Street Norwood, Massachusetts

For more information circle **8** on inquiry card.

AMPHENOL



New 133 Series Plugs and Adapters



143 Series Receptacles for Boards or 133 Series

PRIN-CIR
CONNECTORS

Prin-cirs are unlike any other printed circuit connectors! Engineered to the exacting requirements of major equipment manufacturers, utilizing superior gold-plated contacts, featuring high-strength bodies molded of diallyl phthalate, AMPHENOL Prin-cirs provide *increased* reliability for printed wiring connections. Prin-cirs are available in two series:

RECEPTACLES Heart of these connectors is a new contact with a circle lip entrance for good wiping action and a long spring base. It can't be 'set' or overstressed when used with standard boards, has low millivolt drop and long life. 143 series receptacles of 6, 10, 15, 18 and 22 contacts with four tail styles.

PLUGS AND ADAPTERS Newly available, these mate with the Prin-cir receptacles. May be used for building modular units, right angle stack-ups or cable plug-ins. Molded nylon guide pins are a strong feature. 133 series; 10, 15, 18 and 22 contacts with five tail arrangements.

For Printed Circuits, as for every major component use, make contact with AMPHENOL!

AMPHENOL ELECTRONICS CORPORATION
chicago 50, illinois

Inquiries

These inquiries, representing problems facing readers of **Instruments & Automation**, are published as a free service to our readers.

Conversion of Analog Data to Punched Cards

Reader seeks commercial equipment to convert analog data directly into punched cards. Application involves read-out of signal vs. time records on a strip recorder, at equal intervals. One test run requires approximately 2000 points. Computation is done by IBM equipment. The test frequency does not warrant expensive equipment, but some form of semi-automatic punching of the cards without human readout is desired. A-201

Dynamic Balancing

Instrument maker in charge of test stand with aircraft components manufacturer seeks information on dynamic balancing, high speed bearings, centrifuges, etc. in form of literature, etc. A-202

High-Temp Wire

Engineer in metals research lab requires 200 feet of #10 copper wire to wind electromagnet. Insulation must withstand 450° to 500° C and must give as high a space factor as possible. A-203

Cam-driven Micro Switch

Instrument distributor wants names of manufacturers of kits to actuate micro switch by motor-driven cam. A-204

Plastic Rods

Test engineer requests sources of supply for $\frac{3}{16}$"-dia plastic rod "in bright opaque colors such as red, blue, green, yellow, and others". Quantities required: 10 feet each; 12" lengths are acceptable. A-205

Silver Wire, etc.

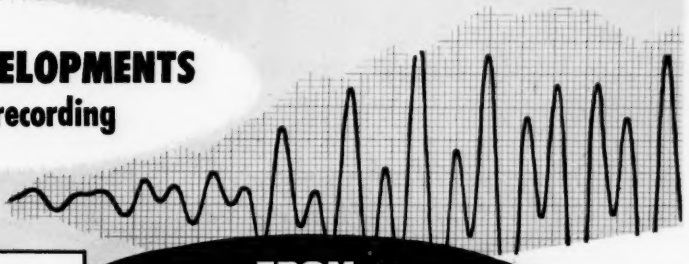
Reader wishes to get in touch with suppliers of 0.0003"-dia silver wire, aluminum tubing for pointers, and balance weights. A-206

Vibrating Reed Tachometers

Australian instruments sales and service company seeks suppliers of Vibrating Reed Tachometers. A-207

← Circle 9 on inquiry card.

TECHNIQUES and DEVELOPMENTS in oscillographic recording



FROM **SANBORN**

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.

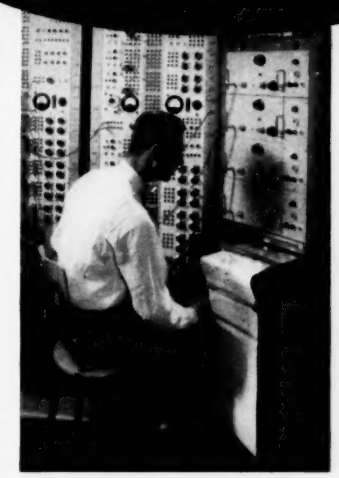
A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."

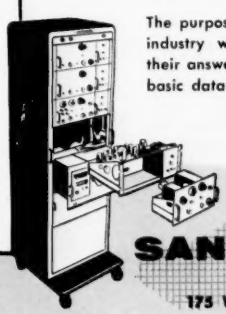
Technical literature and engineering assistance on specific problems are always available from our engineering department.



BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.

The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.



SANBORN COMPANY
INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

For more information circle **10** on inquiry card.

From Electro Instruments comes a revolutionary new concept in digital instrumentation.

transistorized, plug-in modules for precision measurements of dc, ac, ohms and ratios

NOW GET MAXIMUM FLEXIBILITY FOR CUSTOM APPLICATIONS WITH STANDARD, OFF-THE-SHELF MODULES

Check these new specifications and features—the result of thousands of applications and field experience of more than 1,000 digital instruments

Fully transistorized circuits in the new modules provide

1. Increased reliability.
2. Reduced power consumption.
3. Low heat dissipation.
4. Miniaturized packages.
5. Elimination of radio noise and line transients.

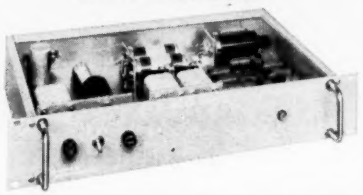
New specifications and features

1. Wider dynamic range covering all voltages from **100 microvolts to 1,000 volts,** resistance range from **10 milliohms to 10 megohms**—in **single** instruments!
2. Input power frequencies from **50 to 400 cycles!**
3. New balance logic speeds down ranging!
4. Automatic ac ranging from 30 to 10,000 cycles.
5. Controlled stepping switch drive increases switch life by a factor of **three!**

Complete flexibility

1. Universal 3½" x 19" x 12" chassis with mounting hardware for **any** rack.
2. **No** modifications required for operating printers, IBM Punches, etc., or for combining with auxiliary E-I input modules or instruments.
3. **All** contacts readily accessible at rear panel on connectors.
4. With auxiliary plug-in modules, digitized data is provided in printed form, punched cards or tape with **no** modification to basic measuring instruments.

BASIC MODULES



Universal Power Module, Models DXA-000 or DXB-000

Supplies *all* power and reference voltages for other E-I modules. Power and reference supplies and stepper drive amplifier are transistorized. Powers one or more modules.

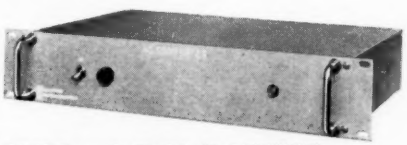
Calibration: Automatic
Reference Stability: 0.01% from 40° to 125° F.
Input Power: 115 volts, 50 to 400 cycles.
Write for Bulletin 175-1

DC Switch Module
Model DVX-400: 4 digits; **Model DVX-500:** 5 digits

Contains Digital Potentiometer. Provides visual in-line read-out of digits, polarity, decimal point. All contacts accessible at rear panel connector. Front and rear panel input connectors. Power supplied by Universal Power Module.
Write for Bulletin 175-2

DC Pre-Amp Module, Model DXX-020

Input: 1 range scale, gain of 10.
Output: 0.0001 to .9999 volts. **Linearity:** 0.01%.
Gain Multiplication Accuracy: 0.01%.
Input Power: 115 volt, 50 to 400 cycles.
Drift: 10 microvolts per hour.
Write for Bulletin 175-5



AC-DC Converter Module, Model DXX-010

A fully transistorized AC-DC converter.

Accuracy: 0.1% of reading, or 2 mv.
Frequency Response: 30 to 10,000 cycles.
Range: .0001 to 999.9 volts.
Zin, AC: 1 meg. on the 1 volt scale, 10 megs. on other scales; 20 mmf.
Ranging: Automatic. **Reading time:** 3 seconds, average.
Write for Bulletin 175-4

Resistance Switch Module
Model DOX-400: 4 digits; **Model DOX-500:** 5 digits

Contains balance circuit, bridge ratio arms. Provides visual in-line read-out of digits, range. All contacts accessible at rear panel connector. Power supplied by Universal Power Module.
Write for Bulletin 175-3

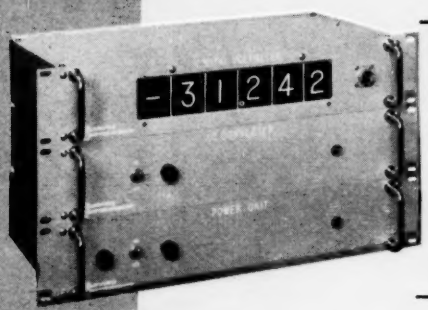
Using E-I's new, transistorized, modular design, any precision instrument for measuring DC, AC-DC, Ohms, DC and AC ratios can be constructed from basic units!

DC Digital Voltmeters

specifications	**Model DVA-400** (Combines Universal Power Supply, Model DXA-000, and Model DVX-400 Modules.)	**Model DVA-500** (Combines Universal Power Supply, Model DXA-000, and Model DVX-500 Modules.)
Display:	4 digits, plus or minus, decimal point.	5 digits, plus or minus, decimal point.
Accuracy:	±1 digit.	±0.01%, plus or minus 1 digit.
Range:	.0001 to 999.9.	0.0001 to 999.99.
Automatic Features:	Ranging, polarity.	Ranging, polarity.

(Adding the E-I Pre-Amp Module, Model DXX-020, increases sensitivity to 10 microvolts.)

DC RATIOMETER – Same modules as Voltmeter except uses external reference. Ratio range: 0.0000 to 1.0999.



AC-DC Digital Voltmeters

specifications	Model DVA-410	Model DVA-510
DC Specifications:	Same as Model DVA-400.	Same as Model DVA-500.
AC Specifications:	Same as Model DXX-010.	Same as Model DXX-010.

(AC RATIOMETER combines Model DVA-400, with two Model DDX-040 or Model DXX-050 Modules. Ratio range is 0.0000 to 1.0999.)

Digital Ohmmeter

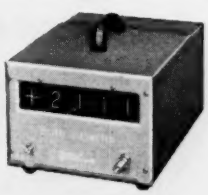
specifications	Model DOA-400 (Combines Model DXA-000 and DOX-400 Modules.)	Model DOA-500 (Combines Model DXA-000 and DOX-500 Modules.)
Display:	4 digits.	5 digits.
Range:	Automatic, 0.01 ohms to 10 megohms.	Automatic, 0.01 ohms to 10 megohms.
Accuracy:	0.01 to 0.1%.	0.01 to 0.1%.

OPERATING MACHINE READ-OUTS

Pictured here is a typical Automation System constructed with standard E-I modules. This system automatically scans and measures 400 channels of AC and DC voltages with punched tape read-out. E-I Model 200 X-Y Recorder provides plotted data. With auxiliary plug-in input and output modules, complete custom data handling systems may be set up. Write for Bulletin 175-6.

NEW HAND-CARRY MODEL

The Mark IV is the ideal companion to the new E-I rack-mounted modular equipment. Compact, weighs only 25 lbs.; 0.05% accuracy. Write for Bulletin 170.



SEE THIS EQUIPMENT AT THE IRE SHOW, BOOTH #3614.

ELECTRO INSTRUMENTS

INC. 3794 Rosecrans, San Diego, California

NEW LITERATURE AVAILABLE—Write for new short form Bulletin 175 containing information about the new Electro Instruments modular design.

For more information circle **11** on inquiry card.

LEWIS

RESISTANCE THERMOMETER AND ACCESSORIES

The Model 62 RT4F Resistance Thermometer is a sturdy, easy to read instrument with a six inch hand drawn scale. It is suitable for use in moving vehicles, is excellent for flight testing or for permanent panel installations. Operated by an ordinary dry cell and calibrated to standard "AN" bulb curves, this instrument is ideal for use with any of the resistance bulbs illustrated below. Other ranges available in °C or °F.

ACCESSORIES — RESISTANCE BULBS AND SWITCHES

Lewis Selector Switches have been used for years in automotive test work as well as in permanent installations. Simple, sturdy construction plus finest materials combine to give long service.

2" SIZE TO 4 POINTS

FREE AIR

3" SIZE TO 20 POINTS

THREADED "AN" TYPE

THREADED "AN" TYPE

4" SIZE TO 28 POINTS

BAYONET TYPE FOR CYLINDER HEAD TEMPERATURE

Lewis Resistance Bulbs are adaptable for use with the 62RT4F Resistance Thermometer or with standard aircraft panel indicators. Special purpose bulbs with stem variations or for high temperature applications are available.

We invite inquiries on your temperature measuring problems.

THE LEWIS ENGINEERING CO.

Manufacturers of *Complete* Temperature Measuring Systems for Aircraft

NAUGATUCK, CONNECTICUT

For more information circle **12** on inquiry card.

INSTRUMENTS and AUTOMATION Trends

Growing concern over air pollution is shown by the report that 68 colleges, universities and research institutes are now engaged in air pollution research as compared to 45 in 1955 and 37 in 1953. Research topics include control of impurities in automobile exhausts, development of instruments to sample and analyze various atmospheres, measurement and analysis of air impurities, and influence of smog on plants and health.

> About one-half the cost of a modern fighter plane is in its instrumentation--radar, fire control, guidance, etc.

American business plans to spend $40 billion in 1957 for new plants and equipment. Instrumentation of such new facilities averages about 10%--or $4 billion. Research and development outlays for 1957 are expected to reach $6 billion (compared to $3 billion in 1953).

> Record 2,947,000 students enrolled in American colleges in fall, 1956. This is 10% above 1955; 39.2% above 1951. Men students outnumber women 2:1.

Council for Financial Aid to Education, Inc., reports that the 1300 colleges, universities, and professional and technical schools need $800 million annual additional endowment in order to meet their needs. Note: $800 million is less than 0.2% of annual gross national product. of $410 billion.

> Internal Revenue reports indicate that in 1956, private industry supported aid-to-education programs at the college level to the tune of $100 million. Comparable figure in 1950 was about $40 million.

A second printing of the 1956 edition of the 1000-page Statistical Abstract of the United States has been ordered (by the Supt. of Documents, G.P.O. $3.75).

> Automation of drilling machines, turret lathes and other precision machine tools for small job lots is a new field for toolmakers, according to Mr. Jones Ashman, President of Advance Industries.

Nuclear reactor data: details of heavy-water manufacture, final stages of separation of zirconium and hafnium, and the liquid thermal diffusion process of isotope separation used to make enriched uranium fuel were among the processes recently declassified by the Atomic Energy Commission to speed the development of civilian nuclear power.

BRISTOL Metagraphic
offer broadest measurement

For temperature, pressure, vacuum, differential pressure, flow,

BRISTOL METAGRAPHIC PNEUMATIC TRANSMITTERS

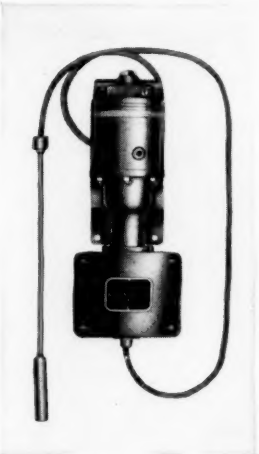
are the measuring centers of the Metagraphic transmission system. They are constructed for friction free operation, and provide superior control and high speed transmission, with low air consumption. Metagraphic transmitters are available for measuring practically any variable encountered in industrial processing.

PRESSURE, VACUUM

Ranges as low as 0 to 3" of water; as high as 0 to 10,000 psi.

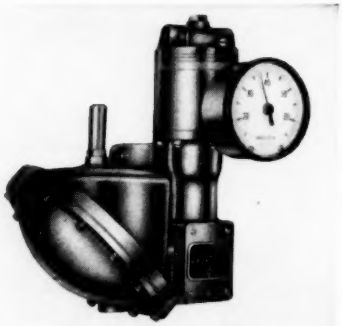
COMPOUND PRESSURE AND VACUUM

Ranges from 15" mercury to 0 to 150 psi.



TEMPERATURE

Ranges as low as —100°F, as high as 5000°F.

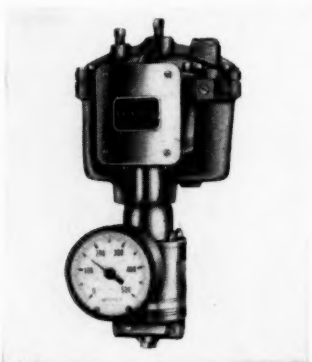


ABSOLUTE PRESSURE

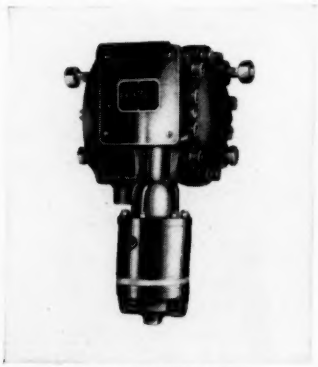
Ranges as low as 0 to 5mm of mercury and up. Available in bronze or stainless steel.

DIFFERENTIAL PRESSURE AND FLOW. Ranges as low as 0 to 1" water and up. Offered in a variety of meter bodies to satisfy almost any requirement or preference, including:

MERCURY MANOMETER



BELL-TYPE ELEMENT



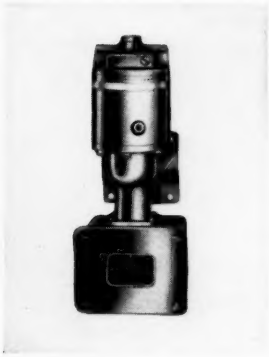
DRY-TYPE METER BODY

For more information circle **13** on inquiry card.

pneumatic transmitters

range and widest coverage

liquid level, and mechanical motion

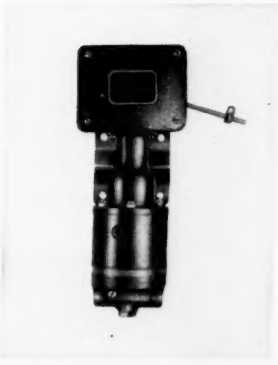


LIQUID LEVEL

Full range of applications from water and other liquids in tanks, open and closed vessels of all kinds; weirs, canals and reservoirs—pressure and bubbler types—for corrosive conditions and solid-bearing liquids.

MECHANICAL MOTION

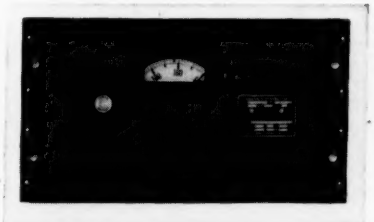
For measuring and transmitting any mechanical motion such as float motion, gate position, or valve stem action, as well as others.



Indicators can be furnished on all transmitters.

MEASURE ELECTRONICALLY, TRANSMIT PNEUMATICALLY

with Dynamaster Electronic Potentiometer Transmitter. Input signal may be a voltage, current or change in resistance, capacitance, or inductance. Output is a pneumatic signal proportional to measurement. Ideal for pH, speed, viscosity, density, strain, force, dew point and other measurements requiring electronic transducer.



Measure almost any variable, transmit universal 3-15 psi* pneumatic signal to a recording receiver or controller

Get the widest variety of pneumatic transmitters on the market in the Bristol 650 Metagraphic line.

They offer you more models and a variety of lower ranges, higher ranges and easily adjustable partial ranges that no other line of pneumatic transmitters can match. Check these Metagraphic advantages:

Easy maintenance. Spare parts are cut to a minimum with the Metagraphic transmitter. The reason: all transmitters are basically the same; only the measuring elements and their housings differ.

Uses standard Bristol measuring elements. The same standard, highly developed and proven Bristol measuring elements that are used in Bristol recording and controlling instruments are used in the Metagraphic transmitter. They are the result of 68 years of research and experience in building hundreds of thousands of instruments for practically every application, and incorporate the latest engineering developments in the field. These high-torque measuring elements, with wide-angle travel, give powerful, positive operation.

Rugged, weatherproof. Bristol Metagraphic transmitters are extremely rugged. They are weatherproof and can be installed anywhere.

Range easily adjustable. The locations of partial ranges are easily adjustable through wide range limits on most transmitters. The span of a given transmitter can also be changed without difficulty. It is therefore no longer necessary to know and specify the exact range in advance, when ordering transmitters.

Thousands of Bristol Metagraphic transmitters are already in operation, giving reliable, trouble-free service. Find out how their advanced design can simplify your measurement, recording, and control problems. Write the Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 6.83

**Other transmitting pressures also available.*

BRISTOL'S

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

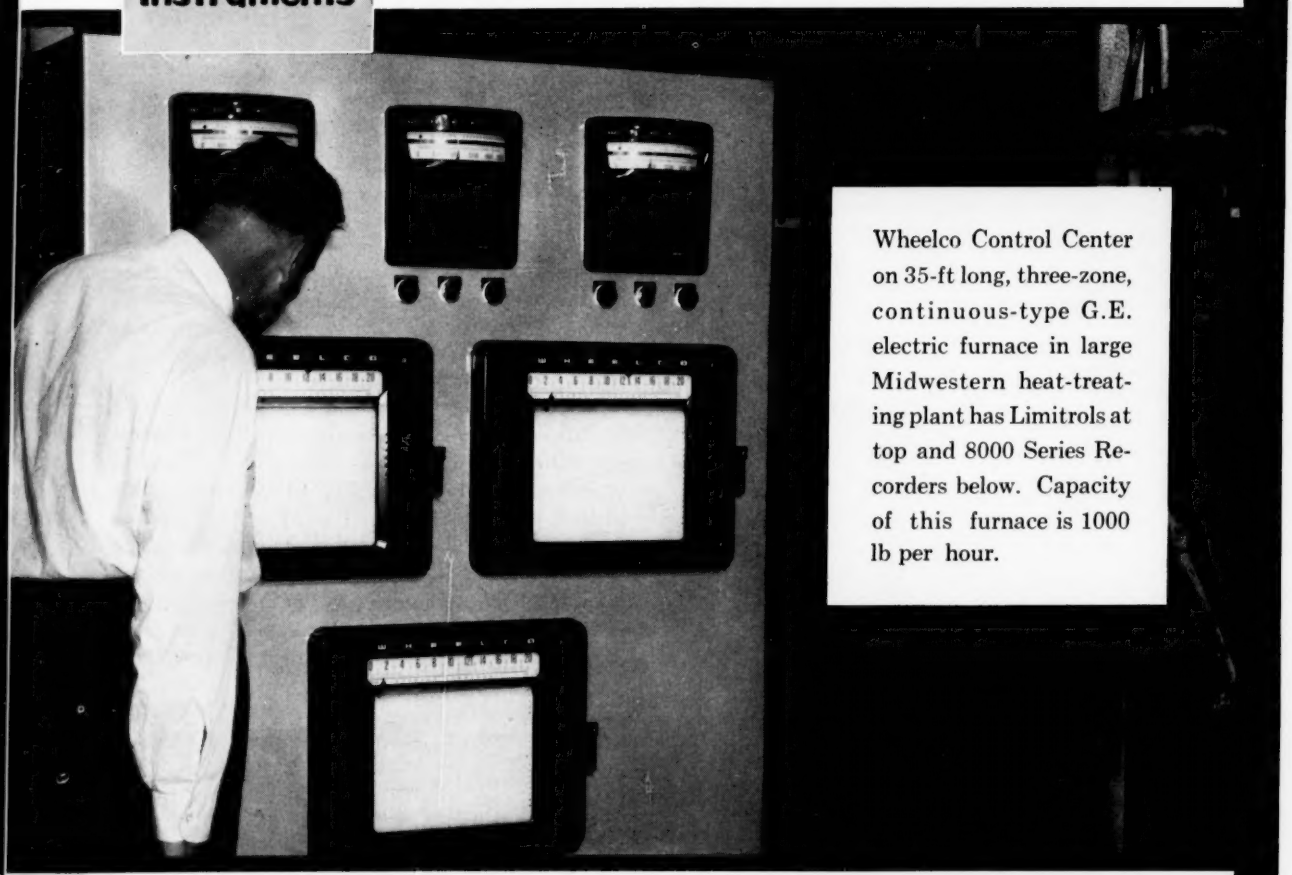
For more information circle **13** on inquiry card.

THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments

From a single instrument to a control center, Wheelco Instruments give you precise, maintenance-free temperature control



Wheelco Control Center on 35-ft long, three-zone, continuous-type G.E. electric furnace in large Midwestern heat-treating plant has Limitrols at top and 8000 Series Recorders below. Capacity of this furnace is 1000 lb per hour.

Forging, salt-bath, carbonitriding, and melting applications all improve their efficiency with Wheelco advanced design

Recording or temperature-controlling applications for either ferrous or nonferrous metals can be brought to peak efficiency with Wheelco Instruments — whether they are the simplest types, requiring a single instrument, or far more complex installations best handled with a number of instruments grouped in a Wheelco-designed and built control center. For an unbeatable combination of instrument qualities, specify Wheelco. A nationwide sales-engineering organization is available to help solve your instrument problems.

You'll find Wheelco Instruments installed as original equipment by leading furnace-builders and preferred by metalworking companies everywhere. Wheelco features, such as plug-in assemblies, use of standard electronic tubes, simple adjustment and scale change, mean less problems for users and are solid reasons for continued preference.

For more information circle **14** on inquiry card.

Better Die-Casting Quality . . .

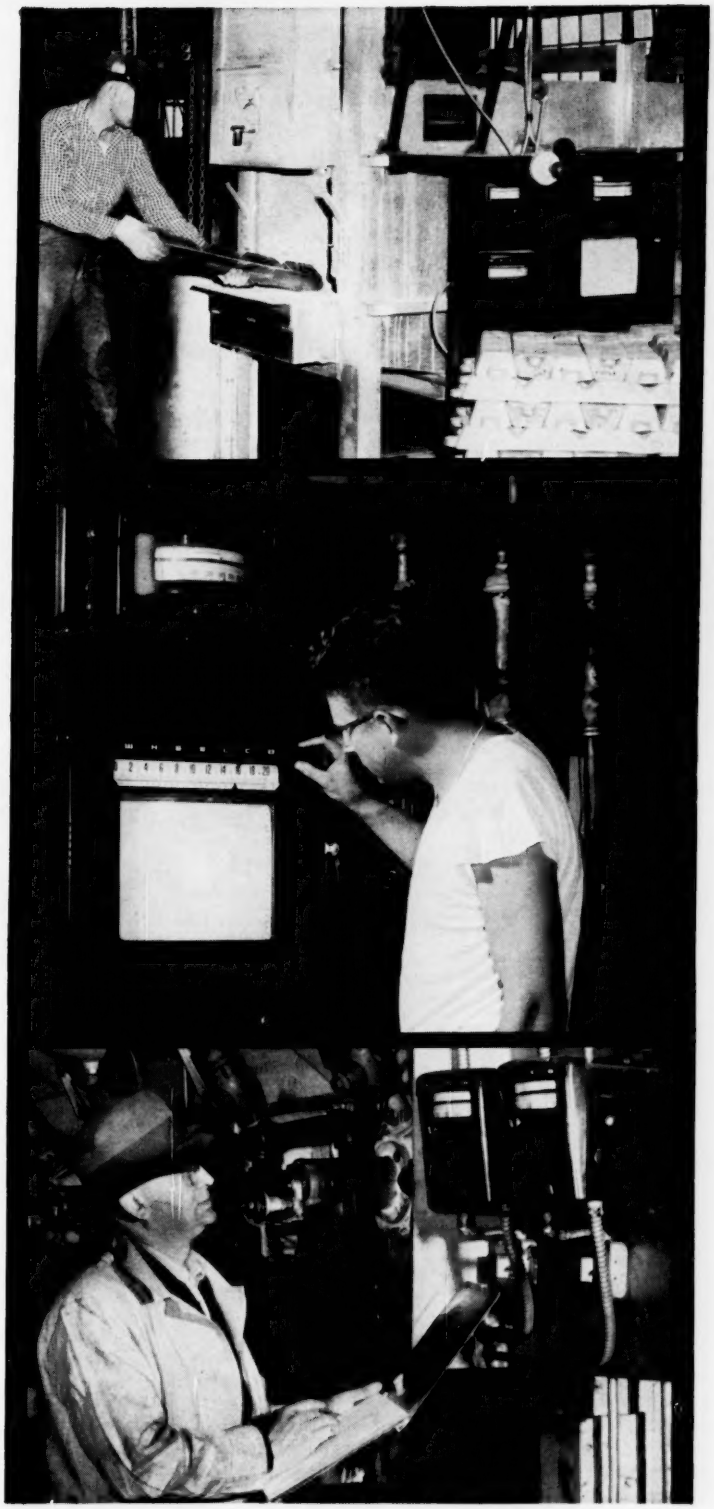
Accuracy of the Wheelco Series 400 Capacitrols that control melting and holding burners improves both production and quality of aluminum die-castings. Aluminum is melted in one furnace chamber and held at precise pouring temperature of 1450° F in the other.

Precise Control for Carbonitriding . . .

Accurate temperature control, insured by use of Wheelco 8000 Series Potentiometer-Recorder, cuts costs and does away with operating problems. Recorder actuates a Barber-Colman Class 2 HYCC power unit that operates a combination air-gas valve. Capacity of radiant-tube furnace is 500 lb per hour. Wheelco Panelmount Limitrol is at top of panel.

Improved Forgings, Lower Fuel Costs...

Three big benefits: better forgings, closer control of temperature, and lower fuel costs result from using Wheelco Model 405 Capacitrols on this large bar-heating furnace. Bar stock heated to 2250-2450° F range is used to make forgings for automotive transmissions.



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Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

For more information circle **14** on inquiry card.

INSTRUMENTS and AUTOMATION News

Principles & Applications 398 to 412
Stock Report 412
New Plants & Mergers 423
People in the News 427

Electronic Calibration Center

WASHINGTON, D. C.—Construction has begun on a $2 million Electronic Calibration Center at the Boulder (Colo.) Laboratories of the National Bureau of Standards in response to the armed services' urgent need for accurately calibrated electronic equipment to be used in radar, aircraft control, and missile guidance.

The primary mission of the Calibration Center will be to calibrate interlaboratory secondary standards for voltage, power, impedance, etc., against master standards to be maintained at the Center. A staff of 50 will be headed by Harvey W. Lance.

The Table shows the equipments that will be used in the various basic frequency ranges.

Electrical Standards 0 to about 30 Kc	High-Frequency Standards About 30 Kc to about 300 Mc	Microwave Standards About 300 Mc to 40,000 Mc and above
Electrical Standards I Standard cells Resistors Inductors Capacitors Potentiometers Bridges	Voltage A-T Voltmeters Micropotentiometers	Impedance Coaxial and waveguide impedance standards Impedance Comparators
Electrical Standards II AC and DC indicating instruments Potential and current transformers Current shunts Voltboxes	Current Thermoelements calibrated against electrodynamometer-type standards	Power Coaxial and waveguide bolometer mounts Self-balancing bridges
	Impedance Special NBS impedance standards Fixed frequency impedance and admittance bridges	Attenuation Coaxial and waveguide measurements using i-f or direct substitution method
	Power Bolometer bridge, conduction and liquid flow calorimeters Power comparator	Frequency Klystron multiplier chain controlled by WWV frequency standard
	Attenuation Null detection, direct substitution system	
	Field Strength Attenuator & linearity standards Standard antenna and standard field methods	

IGY

WASHINGTON, D. C.—J. Wallace Joyce, Head of the National Science Foundation's Office for the International Geophysical Year recently outlined what scientists hope to accomplish in each of the eleven scientific fields to be covered: meteorology, geomagnetism, aurora and airglow, ionosphere, solar activity, cosmic rays, longitude and latitude, glaciology, oceanography, seismology, gravity.

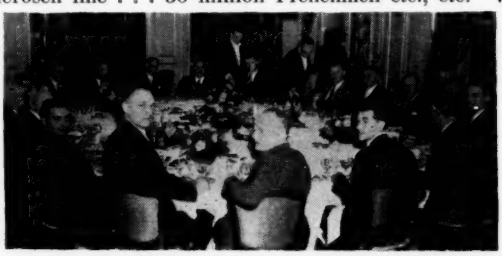
The accumulated data will go to three "World Data Centers" which will evaluate them. One of these centers will be in the United States, one in the USSR, and the third will be divided between Western Europe and Japan. Hopes are high that the fruits of these efforts will be reaped by all mankind as was done from the two antecedents, the First and Second Polar Years in 1882/83 and 1932/33, respectively.

Faster Than Light

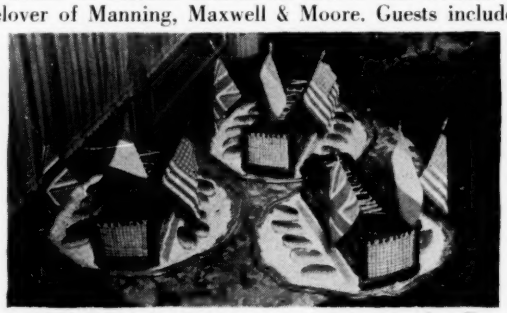
CLIFTON, N. J.—A cathode-ray tube which writes faster than the speed of light has been made available by Allen B. Du Mont Laboratories, Inc. The tube, incorporating electrostatic focus and deflection, utilizes extremely high accelerating voltages to obtain the high light output necessary for very fast writing rates (typical operating conditions: post-accelerator voltage is 30,000 volts and accelerator voltage 7,500 volts).

French Eat Up Microsen Line

PARIS, FRANCE—Karl W. Peterson, sales manager of the Industrial Controls Division of Manning, Maxwell & Moore, Inc., reports that "French are eating up entire Microsen line . . . 50 million Frenchmen etc., etc." We



immediately dispatched editors to check out this development and found that the report is literally as well as figuratively true. Top photo shows a recent luncheon given by MM&M's French Sales Agents, SAPAG, S. A. in honor of Messrs. Charles A. Moore and Newton P. Selover of Manning, Maxwell & Moore. Guests included



representatives of important companies in the French petroleum industry, power industry, electrical industry, and the atomic energy facility.

Piece de resistance of the luncheon was "Gateau Microsen," a delicious cake made in the form of the MM&M Series 130 Strip-Chart Recorder.

Rotor Position Indicator

WASHINGTON, D. C.—An electronic instrument that continuously measures the clearance between the rotating and stationary blades inside a steam turbine has been

at last a completely new kind of regulator!

ACTUALLY THREE REGULATORS IN ONE—*PLUS* MULTIPLE SENSING!

The APR 1010 combines many *new* regulation and sensing systems in *one* versatile package. Here's flexibility of operation never before possible . . . saves space, eliminates instrument duplication, means greater economy in engineering operations.

- **RMS VOLTAGE REGULATION**
- **AVERAGE REGULATION**
- **PEAK REGULATION**
- ***FIVE* PRINCIPAL SENSING ARRANGEMENTS**

1. INTERNAL 2. EXTERNAL 3. REMOTE 4. CONSTANT CURRENT 5. DC

ELECTRICAL CHARACTERISTICS:

Input	**95-130 VAC, 1ϕ (50 or 60 cps ±10%)**
Output	**115 VAC, adj. 110-120V**
Regulation accuracy (RMS, average, or peak, switch selected)	**±0.1% against line** **±0.1% against load**
Distortion	**3% max.**
Load	**0-1000VA**
P.F. range	**Unity to 0.7 lagging**
Recovery time	**0.1 sec.**

Write for complete technical data.

See the new APR 1010 at Booths 2627-9 I.R.E. Show!

SORENSEN & COMPANY, INC. Sorensen® **STAMFORD • CONN.**

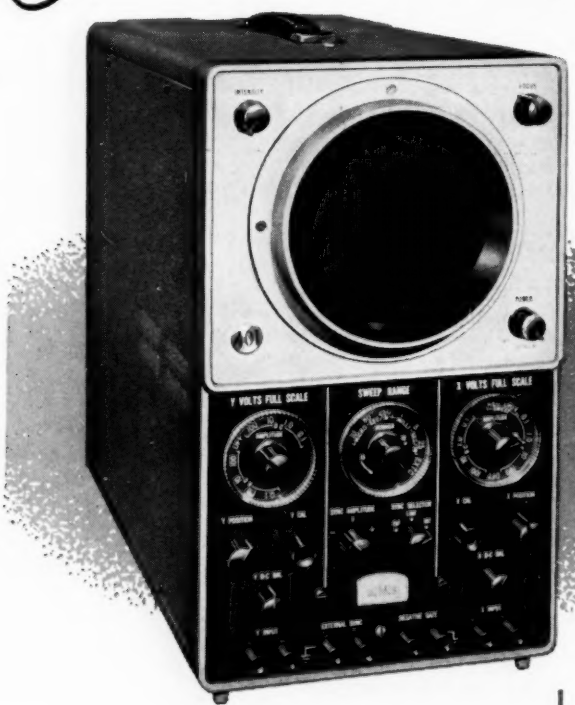
In Europe, contact Sorensen-Ardag, Eichstrasse 29, Zurich, Switzerland, for all products including 50 cycle, 220 volt equipment.

For more information circle **15** on inquiry card.

1957 1958 1959 1960 1961

DEPENDABILITY

Guaranteed for 5 years



The best guarantee in the business!

The 401 is so dependable, we're backing it with a *five year guarantee* on all printed wiring and power transformers . . and, all other components, including the cathode-ray tube, carry a full one-year guarantee.

DU MONT 401

- **IDENTICAL X- AND Y- AMPLIFIERS: Sensitivity, 10 mv/cm. Sinewave response extends flat from dc to 150 kc. Calibration standards built-in for both amplifiers.**
- **SWEEPS: 18 calibrated ranges extending from 50 ms/cm to 4 us/cm. 3 times sweep expansion available.**
- **RELATIVE PHASE SHIFT BETWEEN AMPLIFIERS: Easily set for less than 1° at frequencies below 150 kc.**
- **CATHODE-RAY TUBE: Tight tolerance Type 5ADP-, operated at 3000 volts acceleration.**
- **STABLE OPERATION: Regulation of all power supply potentials, including heaters, provides complete stability.**

Best buy in the medium price range—a general-purpose, low-frequency oscillograph for complete, high-quality quantitative measurement. The 401 offers a new high in precision, ease of operation and convenience as a result of "human engineering"—an exclusive of the Du Mont 400 philosophy of instrument design.

WRITE FOR DETAILS.

$420.00
(slightly higher for 50-cycle areas)

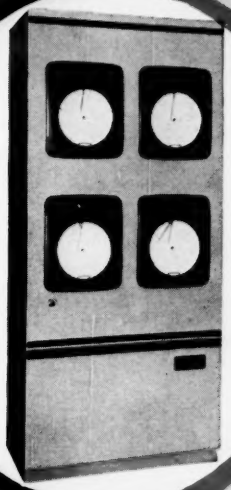
DU MONT® *One of the 400 Series*

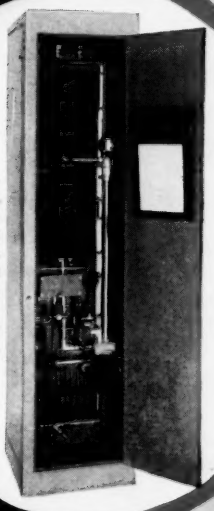
TECHNICAL SALES DEPARTMENT, ALLEN B. DU MONT LABORATORIES, INC. · CLIFTON, N. J.

For more information circle **16** on inquiry card.

NEW! Economical Approach to Better-Engineered Process Control!

Foxboro U-type Cabinet Installations . . .





Typical Foxboro Cabinet Assembly, with all required connections centrally located and tagged to simplify installation in your plant.

Here's the economical way to get instrument *centralization* at its best! New, low-cost Foxboro U-type Cabinets give you the same expert design and assembly that go into Foxboro's largest, most complex control panels. Here's what that means in your plant:

1. A compact arrangement of control instrumentation that saves operators' time — steps up efficiency.

2. Full-length doors at rear of cabinets makes your packaged installation completely accessible.

3. Neat, clean piping and wiring, and orderly arrangement of components, make maintenance extra-easy.

And, of course, your instruments get maximum protection from process "atmospheres" and dust. Foxboro U-type Cabinets are available in three standard sizes for 2, 4, or 6 conventional-size instruments. Specify them on your next order for new instruments — or for instruments now in your plant. Write for full details.

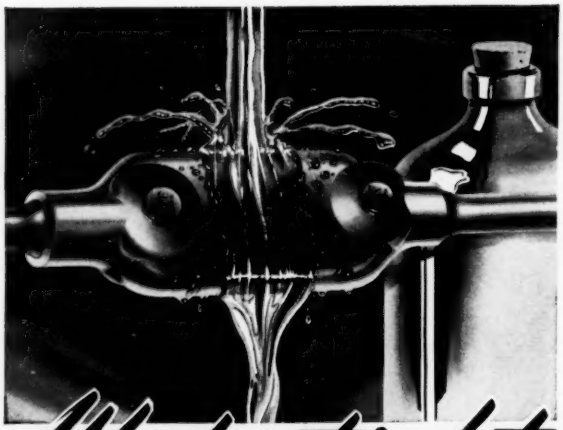
The Foxboro Company,
463 Neponset Ave.,
Foxboro, Mass., U.S.A.

Factories in the United States, Canada and England.

FOXBORO
REG. U. S. PAT. OFF.

PROCESS CONTROL CABINETS

For more information circle **17** on inquiry card.



Watertight

. . . as a CORKED BOTTLE

Moisture cannot penetrate the one-piece Neoprene body of a JOY electrical plug . . . when engaged, even its contacts are enclosed in a protective Neoprene housing through the *cork-like* action of JOY's famous water-seal. Permanently vulcanized to cable, it cannot crack . . . won't lose its shape . . . and requires no special considerations to insure a long life of useful service. A favorite since '26, JOY electrical connectors are now available in styles and sizes for nearly any portable electrical power transmission need. Why risk electrical misfits when the best actually costs less, in the long run?

A DESIGN FOR EVERY NEED

(1) PUSH-LOCK DESIGN
A twist of the wrist locks them together. No. X8164- , illustrated.

(2) PUSH-LATCH DESIGN
Best for small tools and lighting. No. X8142- , illustrated.

(3) ROUND DESIGNS
Excellent for many standard uses. No. X8108- , illustrated.

(4) OVAL DESIGNS
Lay flat. Offer less obstruction. Favorites. No. X8036- , illustrated.

(5) (S.P.B.) DESIGNS
For heavier currents. Have threaded couplings. No. X8223- , illustrated.

Write for complete information today!

Ask for your free copy of Bulletin B59a describing many of JOY'S outstanding Electrical Connectors in detail. It will be mailed promptly without obligation.

CD 354.2

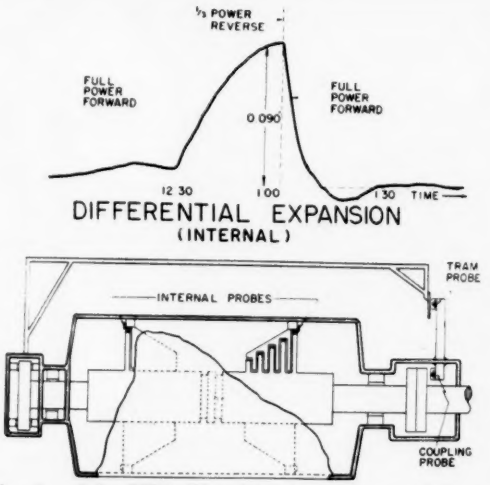
More than 100 years of Engineering experience

JOY MANUFACTURING COMPANY

ELECTRICAL PRODUCTS DIV. • 1201 MACKLIND AVE. • ST. LOUIS 10, MO.

EXECUTIVE OFFICES, HENRY W. OLIVER BLDG., PITTSBURGH 22, PA.

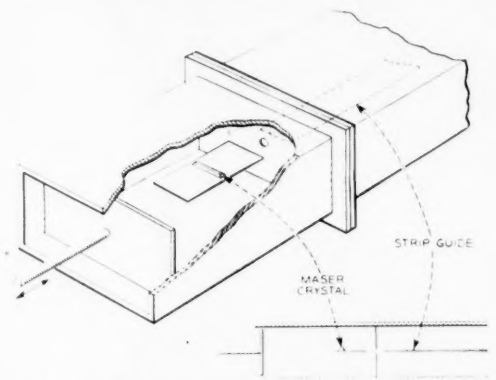
For more information circle **18** on inquiry card.



developed by NBS. The detecting element of the system is a mutual-inductance micrometer probe (in printed circuit form on a ceramic base) that resists high-temperature steam erosion inside the turbine. Designed for the Navy Bureau of Ships by M. L. Greenough and J. Johansen of the Bureau's electronic instrumentation laboratory, with assistance of other sections of the Bureau, this rotor position indicator will aid in the study of steam turbines under actual operating conditions. Picture shows where probes are mounted inside turbine. Tram probe is for checking accuracy of internal probes. Graph indicates differential expansion inside turbine as it is reversed under load.

Developments of Bell Labs

NEW YORK, N. Y.—A new magnetic alloy "Supermendur" (49% Fe, 49% Co, 2% V) will permit reduction in size, and improvements in magnetic amplifiers, switching and memory devices, pulse transformers, and power transformers. The alloy is said to have higher permeability and lower hysteresis losses at higher flux densities than any other material heretofore available. The development is credited to H. L. B. Gould and D. H. Wenny of the Bell Telephone Laboratories.



A device, called a *spin oscillator*, is the latest development in solid-state devices coming out of Bell Telephone Laboratories. Oscillating at microwave frequencies it could result in radically new long-distance communication systems to carry television programs and telephone

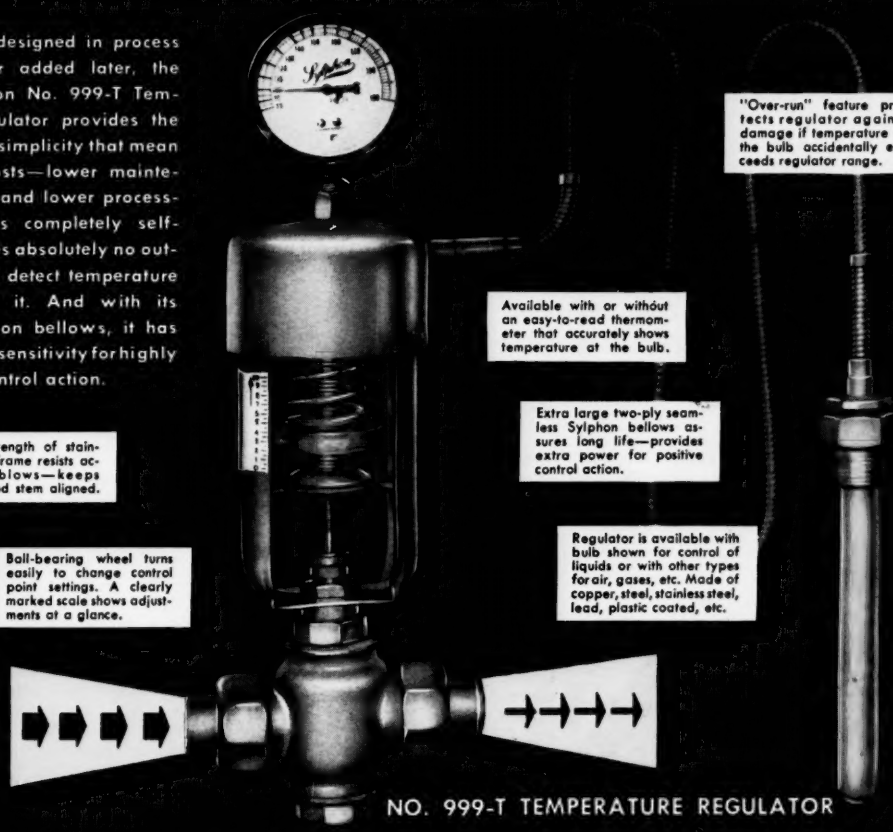
FULTON SYLPHON TEMPERATURE REGULATOR HEADQUARTERS, U.S.A.

CONTROLS TEMPERATURE

UNDER ITS OWN POWER

COMPLETE LINE OF REGULATORS, VALVES, MIXERS, AND CONTROLS FOR LIQUIDS, AIR OR GASES.

Whether it's designed in process equipment or added later, the Fulton Sylphon No. 999-T Temperature Regulator provides the accuracy and simplicity that mean lower first costs—lower maintenance costs—and lower processing costs. It's completely self-contained, uses absolutely no outside power to detect temperature or to control it. And with its famous Sylphon bellows, it has the power and sensitivity for highly responsive control action.



"Over-run" feature protects regulator against damage if temperature at the bulb accidentally exceeds regulator range.

Available with or without an easy-to-read thermometer that accurately shows temperature at the bulb.

Extra large two-ply seamless Sylphon bellows assures long life—provides extra power for positive control action.

Added strength of stainless steel frame resists accidental blows—keeps bellows and stem aligned.

Ball-bearing wheel turns easily to change control point settings. A clearly marked scale shows adjustments at a glance.

Regulator is available with bulb shown for control of liquids or with other types for air, gases, etc. Made of copper, steel, stainless steel, lead, plastic coated, etc.

NO. 999-T TEMPERATURE REGULATOR

Available with 60 F ranges between 20° and 455 F.
Variety of valve types in sizes from ⅛" to 4".

Mr. Controls

Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION
Knoxville 1, Tenn.

Robertshaw-Fulton Controls Co.
FULTON SYLPHON DIVISION
Knoxville 1, Tenn.

☐ Send literature on Temperature Regulators for Industrial Processes, Catalog D-EL

Name_____

Company_____

Address_____

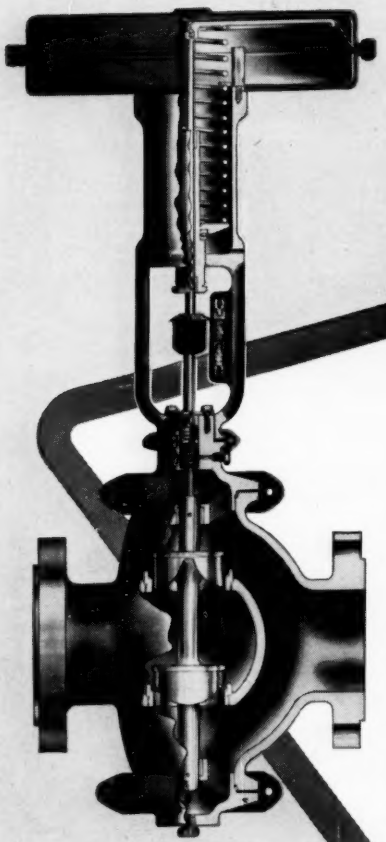
City_____ State_____

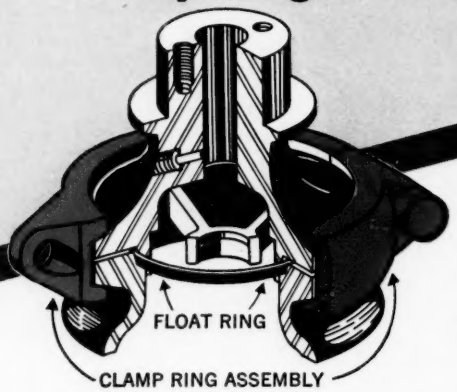
For more information circle **19** on inquiry card.

New Clamp Ring···Float Ring Seal*

On BS&B's *Super* 70 *series*

Diaphragm Control Valves





...Makes Other Valve Closures Obsolete!

The BS&B Super "70" Series Diaphragm Control Valves offer a thoroughly proven concept of pressure sealing, known as the clamp ring — float ring seal, for top and bottom closures.

Tightening of the heavy forged steel clamp ring seals the nickel plated, soft steel float ring into a precision machined, wedge-shaped groove formed by the valve body and the closure plate. Float rings are available in other materials compatible with alloy or stainless steel valve bodies.

Under pressure, the float ring is wedged tighter into its annular groove — thus increasing the sealing force. The higher the internal pressure, the tighter the seal!

This actuation under pressure also creates automatic compensation for thermal expansion under fluctuating temperatures. The seal is maintained under vacuum because initial tightening of clamp ring provides sufficient sealing force to hold a vacuum differential of up to 15 psi. Valves may be disassembled as often as required without damage to the clamp ring — float ring seal.

While a new BS&B exclusive feature in the diaphragm valve field, the float ring seal concept has also been most successfully used over the past several years by other leading manufacturers of high pressure equipment.

* Patented

Why Clamp Rings Are Used On Super "70" Series Valves

The equivalent bolting area of the clamp rings used on Super "70" Series Valves is greater than that of a similarly rated ASA flange — yet is lighter in weight and more trim in appearance. Clamp rings make the valve easier to disassemble for servicing and cleaning because only two bolts must be removed, and permit the valve yoke to be oriented to any convenient position.

For more information on the all-new BS&B Super "70" Series Diaphragm Control Valves, ask your BS&B Sales Engineer — or write for Catalog 70-11.

EFFICIENCY · BS&B · RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-V3

7500 East 12th Street Kansas City 26, Missouri

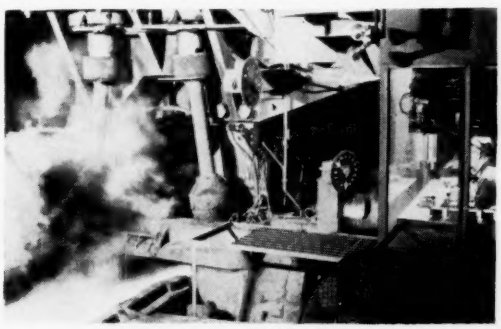
For more information circle **20** on inquiry card.

calls across the continent. It uses a relatively new principle which has been called the "maser" principle (microwave amplification by stimulated emission of radiation). The device operates with electron spins in a paramagnetic crystal. It is expected to have a very low noise

factor. Picture shows the three men whose work has resulted in this development. They are (l. to r.); Drs. Harold Seidel, Derrick Scovil and George Feher.

Card-programmed Roughing Mill

SCHENECTADY, N. Y.—Production of electrical steels at Allegheny Ludlum's Brackenridge Works has been partially automated by a card-programmed preset control on a reversing roughing mill. The control system



is a General Electric development and uses an electronic counter which is preset by punched card data to regulate the screwdown position. Feedback is measured by pulses from a magnetic-pickup toothed-disc transducer and is compared with the preset value. The error in position is converted to a proportional signal which drives the screwdown control. The system is capable of controlling 15 programmed passes from a single card at accuracies of approximately 0.01". It can also be applied to blooming, slabbing, and cold rolling mills. The equipment utilizes 13 vacuum tubes, 25 transistors and two Amplistats in addition to the customary voltage control for the motor.

Canadian Computer Center

OTTAWA, CANADA—Computing Devices of Canada (CDC) recently opened its new computing center whose equipment comprises a Reeves REAC 400, and other small airborne analog computers (which the company builds), plus a digital computer and a NCR 102D with auxiliary equipment. On order is a Bendix G-15D. Pic-

DIALCO's expanded line of sub-miniature lights conform to all applicable Mil Specs. Use T-1¾ midget incandescent lamps—1.3 to 28 V. Spring mounted *Lens-with-Message* is readily positioned *after* installation... Mount from *back* of panel in 15/32" clearance hole; or from *front* of panel in 17/32" hole... 7 lens colors... Shown approx. actual size (top to bottom): No. 134-3830-375-6... No. 101-3830-951... No. 101-5030-951... No. 109-3830-111... No. 111-3830-111... No. 107-1930-951.

Complete details in Brochures L-156 A and L-157.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

DIALIGHT CORP., 42 Stewart Ave., Brooklyn 37, N. Y.

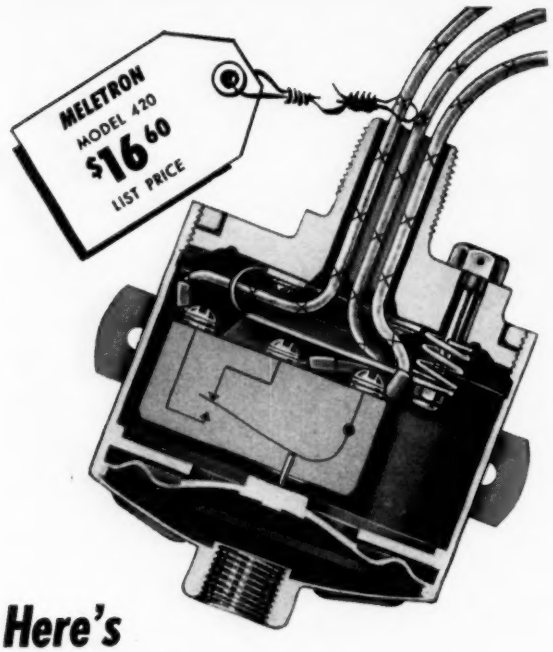
☐ Send brochures on Sub-miniatures ☐ Selection Brochure ☐ Pilot Light Catalogues

Name _____ Position _____

Company _____

Address _____

For more information circle **21** on inquiry card.



Here's the Simplest Diaphragm Pressure Switch

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	**LINKAGES & BEARINGS** which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements.	**LIQUID SWITCHING ELEMENTS** which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS** which make the pressure switch sensitive to vibration.

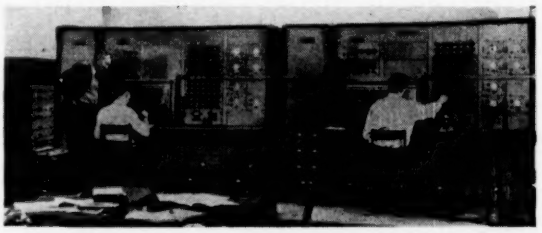
To get complete specifications and operating data ask for bulletins 420-421

BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 Alcoa Avenue, Los Angeles 58, California

For more information circle **22** on inquiry card.



ture shows the REAC and a six-channel Sanborn 150 recorder used with the REAC.

Nuclear News

PITTSBURGH, PA.—The AEC has issued regulations (effective February 28, 1957) for protection against radiation. They contain also definitions of "dose," "rad," "rem," etc.

• The Commission's Experimental Boiling Water Reactor (EBWR) at *Argonne National Lab,* a project of the Commission's civilian program, generated electric power at its full design rating of 5,000 kw late in December 1956 and was officially unveiled to the press on February 9, 1957.

• *Allis-Chalmers* announced an advanced type of nuclear power reactor—a Controlled Recirculating Boiling Reactor (CRBR). Its outstanding feature is its high energy output per unit of volume.

• Next on the list of foreign countries which get nuclear reactors with American help are (1) Brazil (fabricated on the spot by *Babcock & Wilcox Co.*), (2) Greece (a "pool" type built by *American Machine & Foundry*), and (3) The Netherlands which also will buy a "pool"-type reactor. *Leeds & Northrup Co.* will supply the control system for the Danish tank-type reactor.

• *Alco Products, Inc.* has entered into an agreement with *Humphreys and Glasgow, Ltd.,* of Great Britain, to sell the company's nuclear systems outside the North American continent through the latter company's facilities.

• *Daystrom Nuclear,* a division of Daystrom, Inc. will install a "Dart" nuclear reactor in its reactor center at West Caldwell, N. J. Main purpose of the center is to train selected university personnel in reactor use.

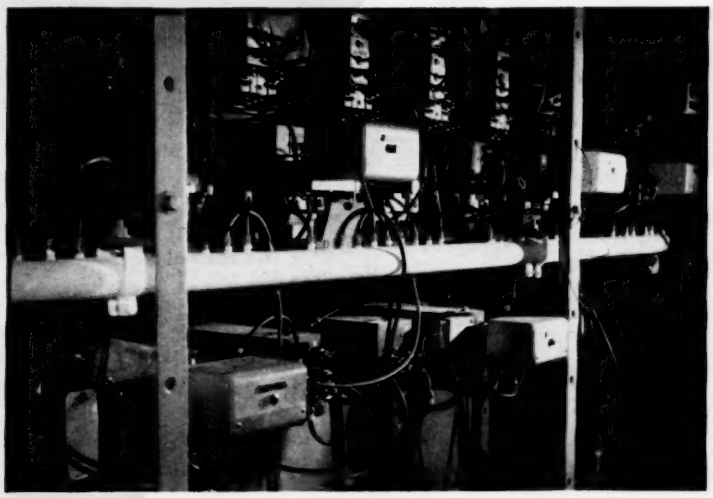
• "Synchrotron" is the name of a new high-intensity proton accelerator to be erected at Princeton University. It is designed to produce at least 50 times the proton current now available either from the Brookhaven "Cosmotron" or the "Bevatron" at the University of California.

• *General Electric* has released information on its operation of the Preliminary Pile Assembly (PPR) at its Knolls Atomic Power Laboratory (KAPL). It has been started up and shut down more than 10,000 times for experimental purposes and has successfully simulated the performance of a large variety of reactors.—The company also revealed that an ITV camera has been installed at the Hanford atomic plant which has the task of patrolling the rear face of the reactor to pinpoint trouble spots before special work crews are sent into the area.

• The first atomic power plant has reached the market for sale as surplus! The Glensville, N. Y., plant of GE

INSTALLATION TIME and LABOR COSTS Reduced 93% by the use of

IMPERIAL Poly-Flo FITTINGS and POLYETHYLENE TUBING



This instrument panel, in a large chemical plant, is one of a great many installations in which Imperial *Poly-Flo* Fittings, used with plastic tubing, have demonstrated surprising versatility and tremendous savings in time and labor through ease of assembly and installation.

INSTALLATION IS AS EASY AS THIS!

. . . Simply cut tubing to desired length with knife or scissors. Bend tubing, which is very flexible, by hand to fit installation. Slip tubing and reversible sleeve over tube support. Nut need only be finger tightened. A wrench is never necessary.

Sensational savings in time and labor are typical of tubing installations made the *Imperial Poly-Flo Way*. Here is an actual documented example: on a chemical unit installation, labor cost of copper tubing was $2.10 per foot. On a similar installation, where polyethylene tubing and Imperial *Poly-Flo* Fittings were used, *the labor cost was only 14½ cents per foot* — a saving of 93% in time and labor.

VERSATILITY . . . the field of application for this fabulous fitting is growing by leaps and bounds. The *Poly-Flo* has been enthusiastically accepted and widely adopted for use with polyethylene and other plastic tubing in instrumentation, chemical plants, refineries, metal working plants and paper mills, to mention a few.

FITTINGS AND TUBING furnished in 1/4", 5/16" and 3/8" O.D. sizes. Tubing supplied in 5 colors — color coding quickly identifies circuits. Recommended for working pressures to 125 psi. — 1/4" O.D.; 100 psi. — 3/8" O.D. Temperatures from —90° F. to +175° F. Tubing is very tough and impervious to most chemicals.

ACCESSORIES include tube racks for mounting from 1 to 10 tubes; quick-disconnect and other shut-off valves; and convenient make-up kit of tubing and fittings.

Ask for Bulletin No. 3025

THE IMPERIAL BRASS MFG. CO. 1204 W. Harrison St. Chicago, Ill.

In Canada: 334 Lauder Avenue, Toronto, Ontario

Emblem of Quality

IMPERIAL

Industry's Most Complete Line of Tube Fittings and Tubing Tools

For more information circle 23 on inquiry card.

You get dependability PLUS in Moeller Bimet Dial

thermometers

because—the design and manufacture of temperature measuring instruments has been our business since 1867.

The sturdy construction, coupled with easy-to-read dials assure continued top performance in accuracy and reliability.

Specify and install Moeller Bimets . . . built upon 90 years of experience. For information mail the coupon, today.

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me the new Moeller Bimet Thermometer Catalog No. 225C.

NAME .....

FIRM .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

For more information circle **24** on inquiry card.

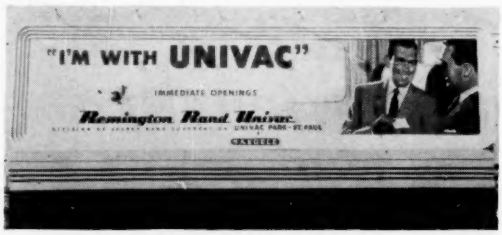
formerly operated for the Federal Government has been deactivated and is being offered for sale.

Education News

• The plan to teach regular high-school courses on automation (on which our editor, Milton Aronson, has been instrumental) is expanding. The *Pittsburgh School Board* has approved the curricula, and the *Allegheny County School Board* has decided to draw up plans for the establishment of technical schools in six sections of the county where students would get supplementary training in addition to their academic classes.

• The *Pennsylvania State Government* is entering the engineer recruitment field in hopes of finding 1500 engineers and engineer assistants to carry out its part of the huge Federal highway construction program . . .

• Billboards such as the one illustrated are now used by the country's major firms in an effort to recruit technical personnel . . .



• A course on the metallurgy of nuclear power reactor materials is slated for the spring semester at the *Polytechnic Institute of Brooklyn.*

• *Wayne State University's* Computation Laboratory is offering three weekly courses on automatic data processing starting June 3 and ending September 14, 1957. This will be the fifth time such summer courses are held.

• *University of Michigan,* College of Engineering, will hold two summer intensive courses in automatic control, scheduled for June 17-22, and June 24-26. Closing date for registration is April 15.

• *Boston College,* Chestnut Hill, Boston, has announced a special two-week intensive course in modern industrial spectrography.

• The *National Science Foundation* announces that it will accept proposals for support of about 15 In-Service Institutes for secondary-school teachers of science and math during the academic year 1957-58 to be held evenings, Saturdays or late afternoons.

News Bits

CERTIFICATES OF MANAGEMENT EXCELLENCE have been awarded to over 400 manufacturing concerns by the American Institute of Management. They include Consolidated Electrodynamics, Minneapolis-Honeywell, Sperry-Rand, Elgin National Watch Co., Rockwell Mfg. Co. and Square D.

ASTE, the American Society of Tool Engineers, celebrating its silver anniversary this year, will charter an Australian chapter by long-distance telephone as part of its Anniversary Banquet program on March 25. Thus two "firsts" are involved, as this will be the first "off-shore" chapter of any American technical society.

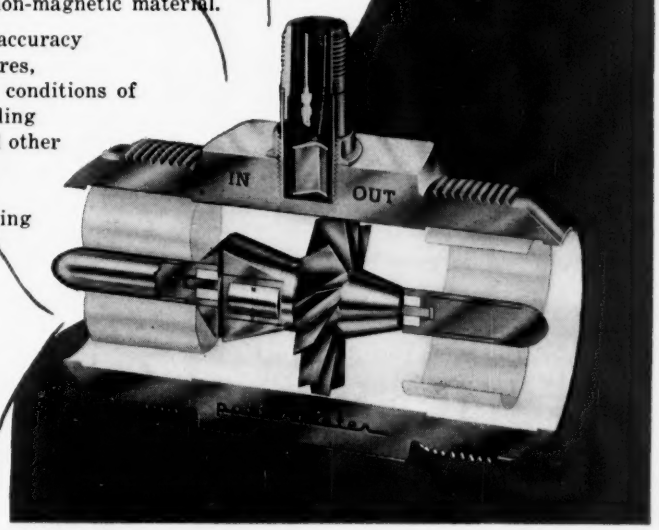
Perfect performa

by PO METE

POTTER Flow Control Systems are currently operating at temperatures as low as −455° F. and as high as 1000° F., at pressures up to 35,000 psi—with no ceiling.

The POTTERMETER Flow Sensing Element, is based on a unique venturi design with a *bearingless*, hydraulically-positioned rotor, and can be made of stainless steel or any non-magnetic material.

POTTER systems feature high accuracy over a wide range of temperatures, pressures, density and viscosity conditions of liquids and liquefied gases, including acids, caustics, hydrocarbons and other corrosives. They are shock and vibration-resistant and can be utilized with a variety of indicating totalizing, recording and/or control instrumentation.



Only POTTER makes the POTTERMETER

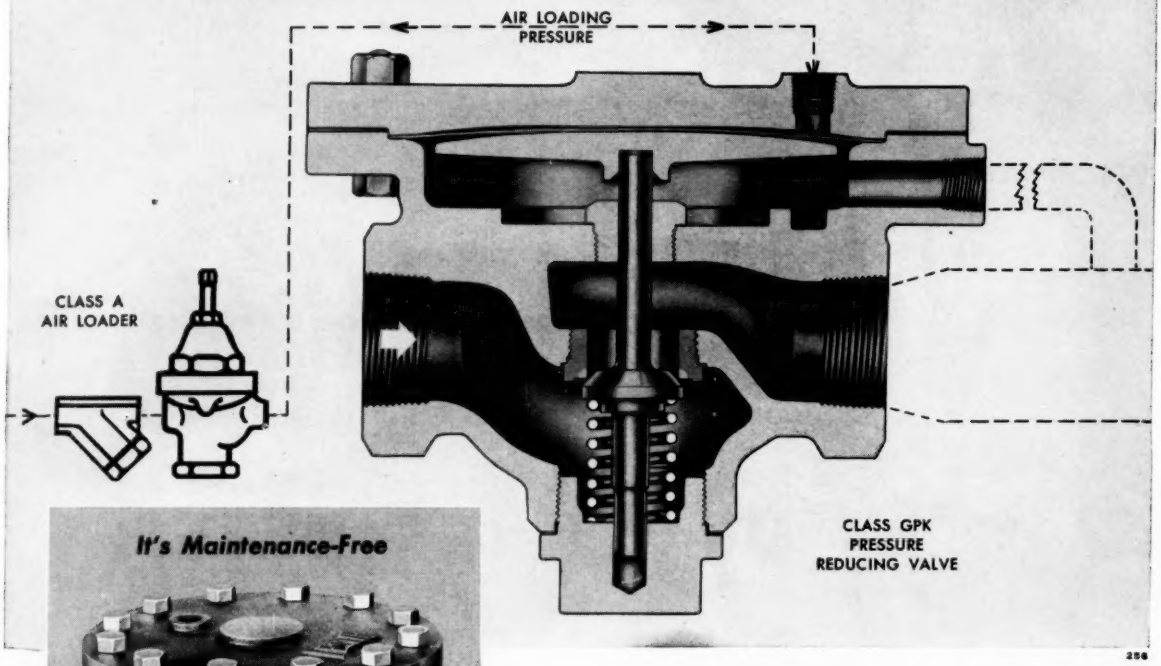
Write TODAY for Bulletin T1

POTTER

POTTER AERONAUTICAL CORP.
U. S. Route 22, Union, New Jersey
MUrdock 6-3010

For more information circle **25** on inquiry card.

Now Leslie brings you this New NO MAINTENANCE* Reducing Valve



You can just put this amazingly simple and compact Leslie Class GPK-A pressure reducing valve on the line and forget it for at least 3 years!

HERE IS AN AMAZINGLY SIMPLE air loaded, diaphragm operated, pressure reducing valve that is virtually maintenance-free for steam heat or process steam application.

Only two moving parts and no seals, no stuffing boxes, no small dirt-catching parts — practically nothing can get out of order! And a stainless steel hardened main valve with highly polished finish minimizes wear.

This new Leslie valve instantly feels the effect of any flow change and responds to changes as small as 0.1 psi. It can be adjusted easily from minimum to maximum of reduced pressure range from a remote point, even a thousand or more feet away.

This valve is used in steam process and heating lines. And, its uses are unlimited for any steam reductions within body material limits (250 psi, 450°F).

Ask your Leslie engineer to tell you more about this amazing valve. He's listed in your classified directory under "Valves" or "Regulators".

***guaranteed no maintenance for 3 years.**

Send for Bulletin 561 today.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 299 GRANT AVENUE, LYNDHURST, NEW JERSEY

For more information circle **26** on inquiry card.

If forward voltage drop is a problem in your diode circuitry...see the

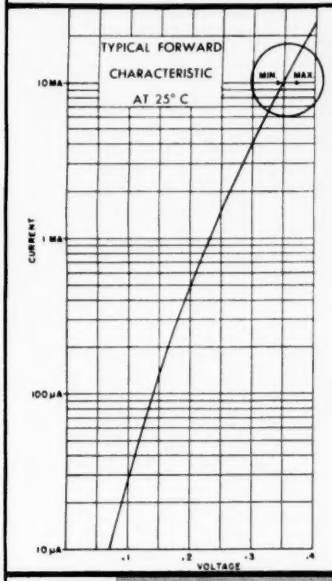
RADIO RECEPTOR

GOLD BONDED

Germanium Diode DR 385

Available now in production quantities for immediate delivery

with controlled forward voltage drop between 0.34 and 0.37V at the 10MA level



Design engineers working with transistorized circuits, computers and other applications will find that RRco. Type DR 385 has extremely low forward voltage drop as well as other desirable features. The specifications speak for themselves!

Characteristics at 25° C	Forward voltage drop @ 10MA	
	Minimum	0.34V
	Maximum	0.37V
	Maximum reverse current at −10V	10UA
	Peak inverse voltage	60V
Maximum Ratings at 25° C	Maximum inverse operating voltage	50V
	Continuous DC forward current	100MA
	Surge current for 1 second	500MA
	Average power dissipation	80MW
	Derating above 25° C	10MW/10° C

DR 385 exhibits fast transient response and similar diodes can be offered fully tested to your recovery conditions.

In Radio and Electronics Since 1922

Further information on DR 385, or any other RRco. diode type will be sent you at once upon request to section A-3.

Semiconductor Division

RADIO RECEPTOR COMPANY, INC.

240 Wythe Avenue, Brooklyn 11, N. Y. • EVergreen 8-6000

Radio Receptor Products for Industry and Government: Selenium Rectifiers • Germanium Diodes Thermatron Dielectric Heating Generators & Presses • Communications, Radar & Navigation Equipment

See us at the IRE Show, Booths 1307 & 1309.

For more information circle **27** on inquiry card.

Precise

TEMPERATURE MEASUREMENTS

. . . with the Rubicon

MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 141.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100

. . . with the Rubicon

PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer —permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

Described in Bulletin 270

RUBICON COMPANY

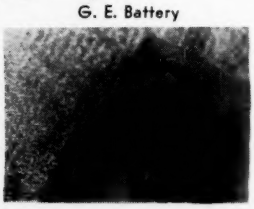
Electrical Instrument Makers

3755 Ridge Avenue Philadelphia 32, Pa.

For more information circle **28** on inquiry card.

SPERRY PRODUCTS, INC. is marketing a bearing tester which, by means of an electronic probe furnishes visual and aural indication of malfunctioning parts. Its main uses will be in preventive plant maintenance and quality control.

Sperry Bearing Tester



G. E. Battery

GENERAL ELECTRIC CO.'s new subminiature solid-electrolyte battery has a projected life of 20 years and is designed for high voltage-to-volume requirements. Consisting of 127 stacked cell units having a silver anode, a cupric bromide and carbon cathode, and a silver bromide electrolyte, it has a charge of one coulomb available, and a potential of 95 volts.

ANIPLA, the Italian Automation Association, is sponsoring a 5-month Automation course at the Milan Polytechnical Institute which will be under the direction of Prof. Dr. Antonio Todisco, recently elected president of the Milan Section. The January issue of "L'Automazione", organ of ANIPLA, presented a reprint of Milton H. Aronson's editorial "Automation and Economics."

Stock Report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

New York Stock Exchange:

SECURITY	Price Range for 1956-57 Thru Feb. 19 HIGH	LOW	AS OF FEB. 19, 1957
ACF Industries	67 7/8	55	62 1/8
Aeroquip Corp.	25 3/4	11 7/8	25 1/8
Allis Chalmers	37⅛	30 1/8	32 5/8
American Chain & Cable	61 3/8	38½	51⅛
American Machine & Foundry	40 3/4	24 1/8	33 3/4
American Machine & Metals	45 3/4	35 1/8	41 3/4
American Optical	40 3/4	33	33⅛
American Telephone & Telegraph	187 1/8	165	176 5/8
Beckman Instruments	43 1/8	25 1/8	39½
Bell & Howell	50 7/8	28½	41½
Bendix Aviation	64 3/8	48½	61½
Boeing Airplane	65 3/8	45 3/8	53½
Bullard	38 3/8	22	23⅛
Bulova Watch	23	20 1/8	20 3/8
Burroughs	46 7/8	28½	36 1/8
Carborundum	45 5/8	31½	40
Cincinnati Milling Machine	55½	37⅛	41½
Clevite	24⅛	18	19
Columbia Broadcasting "A"	34½	22 5/8	32
Consolidated Electronics	36½	26½	32 3/4
Cornell Dubilier	40 1/8	23	23 5/8
Corning Glass	87⅛	57⅛	60 3/4
Curtiss-Wright	49 3/4	26 3/4	43½
Cutler Hammer	65	53	54 3/4
Daystrom	34	22	31
Dobeckman	39¼	24½	25 3/4 - 26⅛ (1)
Douglas Aircraft	95 5/8	72½	80½
Eastman Kodak	100 3/4	75 3/4	84 3/8
Eaton Manufacturing	66	51½	56
Electric Auto Lite	41 3/8	30⅝	33 3/4
Elgin Watch	17 3/8	11	12½
Food Machinery & Chemical	77	51	55 3/4
Gamewell	36¼	25 5/8	31⅛
Garrett	54½	38	48
General Dynamics	61 5/8	45 1/8	61
General Electric	65½	52 3/8	56⅛
General Instrument	10 1/8	6¼	6½ - 6 5/8 (1)
General Mills	71 3/4	61	64½
General Precision Equipment	53½	34½	38 5/8
General Railway Signal	34	26 3/8	29 3/4
General Telephone	46	38	40 3/4
General Time	34 5/8	26¼	30⅛
General Tire	72½	47⅛	68 3/4
Goodyear	84	60	74 7/8
Hamilton Watch	28½	19	26 3/4
Hoffman Electronics	25 3/8	17 3/8	17 3/8
International Business Mach.	550	400	522
International Tel & Tel	37 3/8	29½	31 1/8

Continued on page 414

How to use a Wave Analyzer on an Ocean Wave

(or any low frequencies from 1/10th to 5 cycles per second)

A head-on attack on this problem will soon uncover the disconcerting fact that wave analyzers just don't come this big. Those of a more comfortable size generally operate on frequencies of five cycles per second and more.

But frequencies as low as 1/10th cycle per second – like earthquake waves, ship motion, and low-frequency vibrations of large machines and structures can be fed to conventional wave analyzers with completely satisfactory results. Magnetic tape recording provides an essential conversion step between.

Bell Aircraft Corporation's magnetic-recorder installation aboard the SS Mariposa for study of ship motion.

Speed change on the Ampex FR-100 is accomplished quickly and easily by a selector knob and switch.

Two Ampex FR-100 magnetic recorders were purchased and installed aboard the SS Mariposa for Bell Aircraft Corporation's study of ship motion at sea. The frequencies encountered were far below one cycle per second. These were recorded at the lowest tape speed on the recorder (1⅞ in/sec.). Reproducing the tape at the highest tape speed (60 in/sec.) multiplied the frequencies by 32. Recopying onto the second recorder and speeding up again increased the total speedup to 32 x 32 or a total of 1024. As an example, a frequency of 1/10th cycle per second became approximately 100 cycles per second and was easily separated and measured by wave-analysis equipment.

The Ampex FR-100 recorder has six standard speeds from 1⅞ to 60 in/sec. in the ratio of 1, 2, 4, 8, 16 and 32. Recopying accomplishes further multiplication by powers of two. Even a second recopying is perfectly feasible just in case you are interested in a frequency multiplication of 32,768.

Putting low frequencies onto magnetic tape requires an FM-carrier recording. On the Ampex FR-100 this is conveniently provided by plug-in amplifiers. Frequency response at 1⅞ in/sec. tape speed is 0 to 312 cycles/sec. At 60 in/sec. it is 0 to 20,000 cycles/sec. Besides its ability to record very low frequencies, FM carrier recording has the very desirable attribute of high instantaneous amplitude accuracy. Thus, the reproduced waves retain their original form very accurately through any amount of speedup.

If you have a problem that might be solved by data speedup, we would be pleased to furnish further information. Others of magnetic tape's remarkable capabilities will be the subjects of a continuing series of these bulletins. Would you like copies mailed direct? Write Dept. BB-3

INSTRUMENTATION DIVISION
AMPEX CORPORATION
FIRST IN MAGNETIC TAPE INSTRUMENTATION
934 CHARTER STREET • REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

For more information circle **29** on inquiry card.

REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

Temperature Ranges	−150°F. to 150°F., 70°F. to 370°F., 100°F. to 650°F. Read temperature on continuous, 12-inch indicating scale that rotates against a fixed index pointer in a vertical and centered location.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment	Calibrated dial rotated against a fixed index.
Calibration	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation	Automatic compensation for ambient temperatures.

SEND FOR NEW Catalog 200 for full information on the E32N and other remote bulb temperature controls.

UE® United Electric Controls COMPANY
81 SCHOOL STREET, WATERTOWN, MASS

For more information circle **30** on inquiry card.

New York Stock Exchange:

Continued from page 412

Lockheed Aircraft	58 7/8	43½	47 5/8
Magnavox	41	31½	38
Minneapolis Honeywell	90½	58	77 1/8
Minnesota Mining & Mfg.	75½	58	60
Motorola	51 3/4	35 3/4	37½
National Acme	82	62	69½ - 70½ (1)
National Cash Register	59	34 1/8	49
North American Aviation	49 7/8	30½	31
Northrop	29 1/8	21½	26 5/8
Otis Elevator	50 3/4	33½	41½
Philco	36½	15 1/8	15½
Radio Corp. of America	50 3/8	31 5/8	32 7/8
Raytheon	20 7/8	13	17½
Rheem Manufacturing	37 1/8	17 3/8	17 7/8
Robertshaw Fulton	28 5/8	21½	27
Sangamo Electric	37½	29½	32½
Sperry Rand	29 1/8	20	20 3/4
Square D	32 7/8	22 5/8	29 1/8
Standard Coil Products	12 3/4	6½	7 1/8
Starrett, L. S.	73 3/4	43 3/4	65
Stewart-Warner	39½	30½	32 5/8
Sylvania Electric	55 7/8	39 5/8	40 3/4
Telautograph	15½	6 3/8	6 7/8
Texas Instruments	18 3/8	11 5/8	16 3/8
Thompson Products	80	40 3/8	74 3/4
Tung-Sol Electric	36 3/8	27	28½
Underwood Corp.	44	20 7/8	24½
Union Carbide & Carbon	133 3/8	100 5/8	105 7/8
Western Union	22½	17½	19
Westinghouse Air Brake	36 3/8	26½	26 7/8
Westinghouse Electric	65 7/8	50 7/8	53½
Worthington Corp.	60½	41 1/8	54

American Stock Exchange:

Price Range for 1956-57 Feb. 19

SECURITY	HIGH	LOW	AS OF FEB. 19, 1957
Air Associates	13½	8	8
American Meter	41	31½	32 - 32½ (1)
Arc Equipment	24	17½	18½
Belock Instrument	19 3/8	11 3/4	11 3/4
Benrus Watch	10 3/8	7	7 1/8
Breeze Corp.	9 1/8	5 3/4	6 1/8
Clark Controller	37	16½	26
Clarostat Mfg.	5	3 1/8	3 3/4
Clary Corp.	6 7/8	4½	4 3/8
Consolidated Electrodynamics	40	21	33½
DuMont Laboratories	10	4 3/8	5½
Dynamics Corp. of America	8 3/8	5 5/8	6 3/4
Electronics Corp. of America	24½	9 5/8	10 1/8 - 10½ (1)
El-Tronics	9 7/8	3	3 1/8
Fairchild Camera & Instrument	25 7/8	16 3/4	17
Globe-Union	22	16 5/8	17
Haseltine Corp.	48	30½	31½
International Resistance	8½	4½	5 3/8
Lear, Inc.	10½	7½	7 3/4
Litton Industries, Inc.	35½	23	34½
National Research Corp.	29 3/4	16½	21½
Neptune Meter	36	28	28 3/4
New Haven Clock	2½	⅛	5/16
Nordon-Ketay	14 7/8	7 3/8	8 1/8
Nuclear Corp. of America "A"	2½	3/4	15/16
Pneumatic Scale	26½	23 3/4	23 5/8-24 3/8 (1)
Reliance Electric	38	36	37 7/8
Servo Corp. of America	7 3/4	4 5/8	5
Servomechanisms	13½	8½	10
United Shoe Machinery	61 5/8	40½	44
Wallace & Tiernan	32½	19½	26
Waltham Watch	5	1½	1 5/8

(1) Bid and Asked

February 18, 1957

OVER-THE-COUNTER	BID	ASKED
Aerovox Corporation	4½	4 3/4
Aircraft Radio Corp.	19	20½
Argus Corp.	16½	18
Barry Controls, Inc.	9½	10
Eitel-McCullough Co.	34	36
Electronics Associates, Inc.	55	57½
Elox Corp. of Michigan "A"	9½	10
Elox Corp. of Michigan "B"	9 3/8	9 7/8
Erie Resistor Corp.	19	20½
G. M. Giannini	12 7/8	13½
I-T-E Circuit Breaker	32½	33½
Liquidometer Corp.	8	8 7/8
P. R. Mallory & Company, Inc.	40 3/4	41 3/4
W. L. Maxson Corp.	8½	9
Penn Controls, Inc.	19½	21½
Speer Carbon, Inc.	29½	30½
Sprague Electric Co.	31	32
Taylor Instrument Co.	61	64
Telecomputing Corp.	4 1/8	4 3/4
Topp Industries, Inc.	8 3/4	9 3/8
Varian Associates	15½	16½
Vitro Corp. of America	18½	22

Do you have an unsolved "X" spot in your design?
...A place where you would put the "ideal" relay—if you had it?

TYPE J DESIGNS TO MEET WIDE DESIGN REQUIREMENTS

Standard Type J Relays

Twin contacts (Palladium standard). Rated current-carrying capacity: 4 amperes, 150 watts.

Power Type J Relays

Heavy-duty contacts riveted to springs. Code 18 (Silver). Rated current-carrying capacity; 10 amperes, 27½ volts d-c.

Type J Video Relays

For switching video and other high-frequency currents.

CLARE Type J Relays have been filling difficult "X" spots in industrial designs for more than a decade.

Processed of the most positive of all twin-contact designs, the CLARE Type J Relay has all the desirable features of a telephone type relay—yet greatly reduced in bulk.

Many basic design ideas have been improved by this relay—a CLARE original—whose wide acclaim has provoked a lot of imitators but never an equal—whose many distinctive features have provided an eminently satisfactory solution to many perplexing problems involving efficient, long-life relay operation.

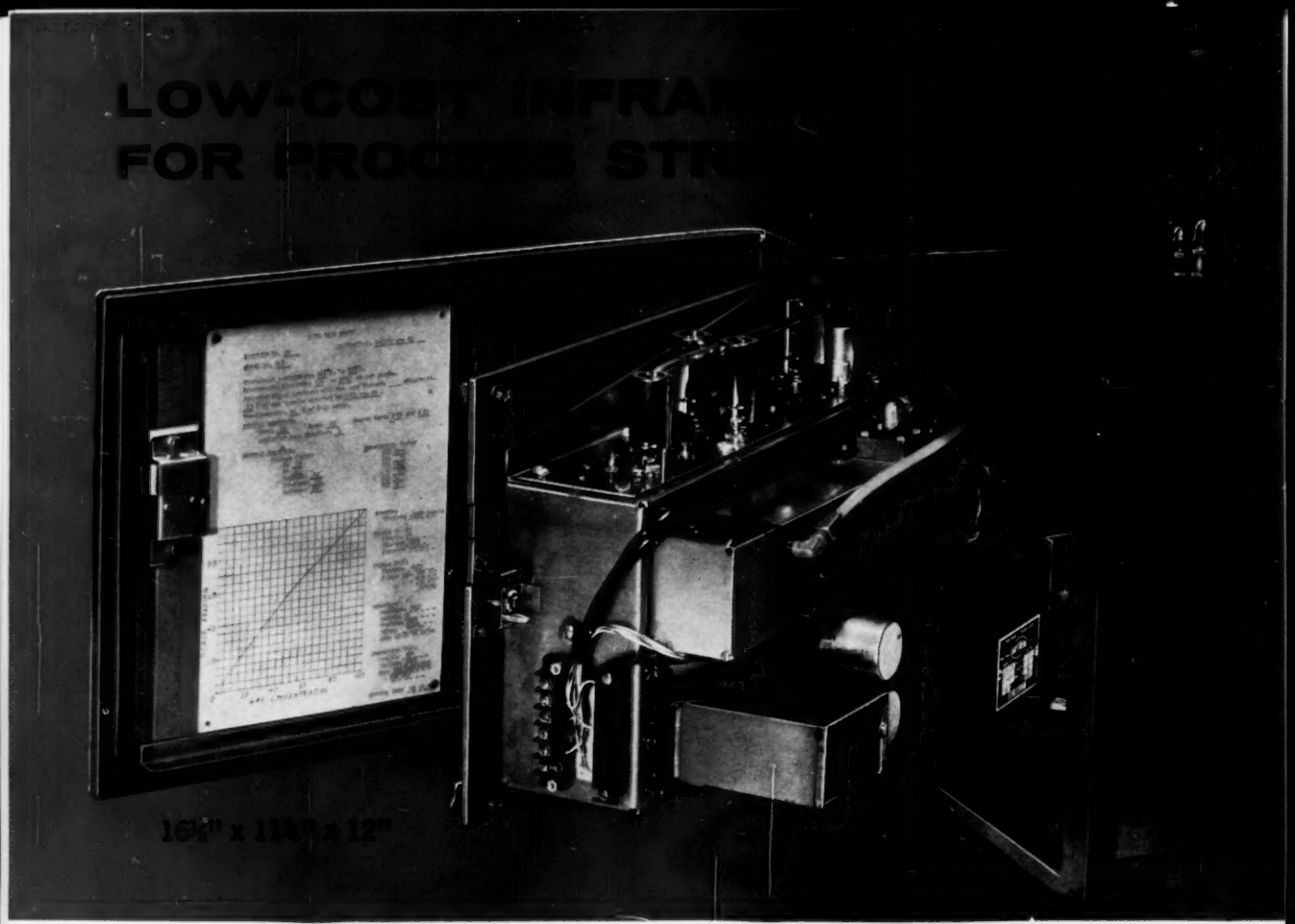
Let us work with you to pick the best relay for YOUR important relay requirement. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable address: CLARELAY.

Write for Engineering Data Book and Bulletin 119

CLARE RELAYS

FIRST in the industrial field

For more information circle **31** on inquiry card.



New M-S-A® LIRA Model 200 features unitized construction for easy operation

This deflection type infrared analyzer provides automatic, continuous, high-speed, accurate analysis for a single component in a simple or complex mixture of gases or liquids. Ideal for process measurement and control, quality control, and the measurement of toxic and combustible gases or vapors in ranges from a few parts per million to 100% of gas.

Completely self-contained, the Model 200 includes facilities for electrically checking the performance of each part of the system. Speed of response is 90% of final reading in 5 seconds. Noise level is less than 1% of full scale. Zero drift is less than 1% of full scale in 24 hours. Accuracy is ±1% of full scale. Warm-up time is 30 minutes.

Service and maintenance are quick and easy on the new M-S-A LIRA Analyzer Model 200, thanks to design simplicity and small compact size. Unitized construction places amplifier, optical bench power supply and zero calibration controls all in readily accessible units on a single swing-out chassis.

Also available is the Model 100 incorporating the Null Balance principle for extreme sensitivity, stability and selectivity.

If you're looking for improved product quality, lower processing costs, or increased safety in your operation, write for new M-S-A LIRA booklet for more detailed information.

CONVENTIONAL CASE contains large 6" illuminated meter with conveniently mounted zero and range controls.

EXPLOSION-PROOF CASE is slightly larger than conventional case and has tamper-proof lock. All controls are easily accessible through the explosion-proof enclosure.

INSTRUMENT DIVISION

MINE SAFETY APPLIANCES COMPANY

Pittsburgh 8, Pennsylvania

At your Service: 76 Branch Offices in the United States

For more information circle **32** on inquiry card.

FACTS

about

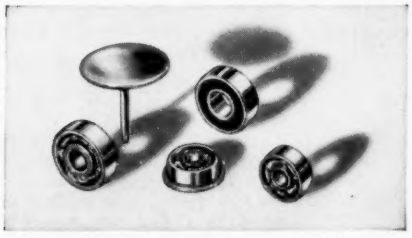
NEW DEPARTURE BALL BEARINGS

NEW DEPARTURE IS A HELPING HAND IN MINIATURIZATION

Volume is one of the big reasons why New Departure is the preferred source for miniature ball bearings.
And, of course, another big reason is ultra-precision! Despite their small size ($\frac{5}{32}$" to $\frac{1}{2}$" O.D.), New Departure miniature bearings are fully precision-ground, lapped, and honed to within tolerances of ABEC 5 or better.
Actually, precision starts with proper preparation of the stainless steel, where optimum metallurgical characteristics are assured by exacting heat treat equipment and processes. Finished bearings undergo rigorous testing and microscopic inspection on special equipment. All assembly and packaging steps take place in completely air-conditioned and pressurized areas to assure keeping out contaminants.

However exacting your performance requirements, call on New Departure for miniature bearings unexcelled for precision, accuracy, and long life. New Departure, Division of General Motors, Bristol, Connecticut.

SEE "WIDE WIDE WORLD"
SUNDAYS—NBC-TV



New Departure Division
General Motors Corporation
Bristol, Connecticut
Att. Dept. D

Gentlemen: Please send me free catalog on miniature bearings.

Name_____ Title_____

Company_____

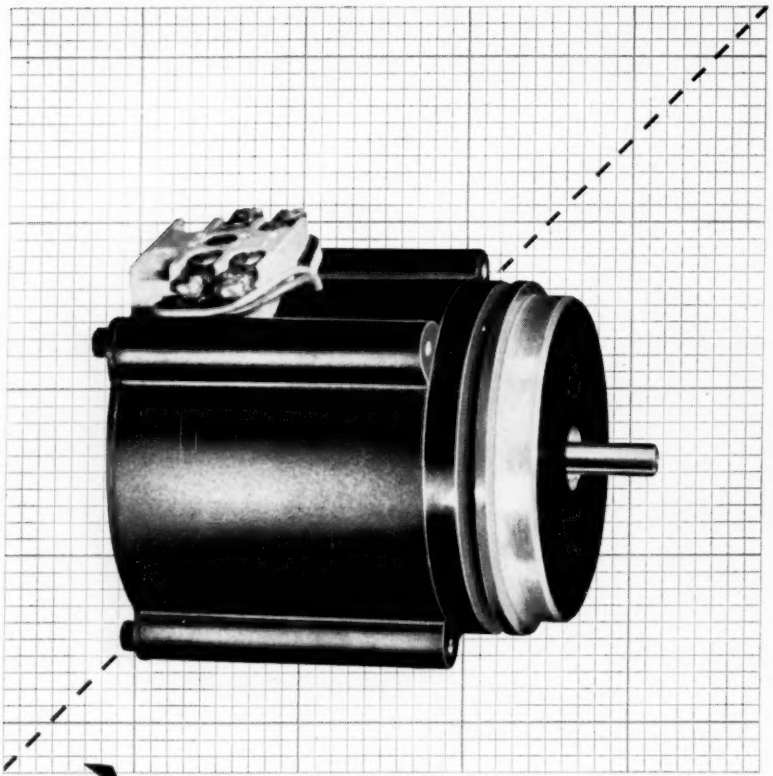
Address_____

City_____ Zone____ State_____

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

For more information circle **33** on inquiry card.



NEW **DIEHL**

A. C. TACHOMETER

A useful component in servo systems and with linearity accurate enough for use as an integrator in many computing problems.

This tachometer can be furnished separately as shown or mounted integrally with an A.C. Servomotor. Temperature compensated units are also available.

Note these specifications:—

Input	115 volts, 60 cycles
Output	6.0 volts per 1000 RPM
Linearity	± 0.5% above 1000 RPM and ± 0.25% between 50 & 1000 RPM
	Total Residual Voltage — 50. millivolts

A similar unit has been developed for 400 cycle operation.

Send for additional engineering data.

Diehl **DIEHL MANUFACTURING COMPANY**
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

other available components: • AC SERVOMOTORS • AC SERVOMOTORS WITH AC TACHOMETERS AC SERVOMOTORS WITH DC TACHOMETERS • AC AND DC TACHOMETERS DC SERVO SETS • RESOLVERS

IA 357

Booth 2237—1957 Radio Engineering Show, New York Coliseum, March 18-21

For more information circle **34** on inquiry card.

Events

For Computer Events See Page 497

March 26-27
Conference on Instrumentation for the Iron & Steel Industry sponsored by the Pittsburgh Section of I. S. A., Hotel Roosevelt, Pgh. 22, Pa. For information write Fred D. Marton, 845 Ridge Ave., Pgh. 12, Pa.

April 2
Meeting on Photographic Process in Emission Spectroscopy at the Hotel New Yorker. For information write Frank M. Biffen, Publicity Chairman, SAS, Johns-Manville Res. Center, Manville, N. J.

April 8-11
14th Annual British Radio and Electronic Component Show, Grosvenor House and Park Lane House, Park Lane, London, W. 1. For information write Andrew Reid, Radio Industry Council, 17 Fleet St., London, EC4, England.

April 9-10
Conference on Electronics in Industry, held in the IIT Commons Bldg., Chicago, Ill. For information write Armour Research Foundation of Illinois Inst. of Technology, 10 W. 35th St., Chicago 16, Ill.

April 10-12
First National Nuclear Instrumentation Conference, Atlanta, Georgia, sponsored by ISA. For information write Herbert S. Kindler, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

April 11-13
Ninth Southwestern I.R.E. Conference and Electronics Show, Shamrock Hotel, Houston, Texas.

April 12
National Nuclear Instrumentation Conference, Hotel Biltmore, Atlanta, Ga. For information write Herbert Kindler, Instrument Society of America, 313 6th Ave., Pittsburgh 22, Pa.

April 14-16
National Symposium on Telemetering and Exhibits, Sheraton Hotel, Philadelphia, Pa. For information write Fred Fanella, General Electric Co., Special Defense Projects Dept., 3198 Chestnut St., Phila. 4, Pa.

April 22-24
IRD's 3rd Annual Conference on Control System Applications, Northwestern Univ., Evanston, Ill.

April 24-26
Southern California Electronic Conference and Show, Balboa Park, San Diego, Calif. For information write 7th Region IRE Conference, U. S. Grant Hotel, San Diego, Calif.

April 25-26
Annual Technical Meeting of Inst. of Environmental Engineers, La Salle Hotel, Chicago, Ill. For information write Henry F. Sander, Pres. IEE, Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

April 27-May 2
39th Annual Meeting of the Scientific Apparatus Makers Association, Greenbrier, White Sulphur Springs, W. Va.

April 29-May 2
Third Flight Test Instrumentation Symposium, Statler Hotel, Los Angeles, Calif. For information write Eugene Spencer, Los Angeles Section, Instrument Society of America, 5225 Wilshire Blvd., Los Angeles 36, Calif.

May 1-3
Electronic Components Symposium, Morrison Hotel, Chicago, Ill. For information write J. S. Powers, Electronic Components Symposium, 84 E. Randolph St., Chicago 1, Ill.

May 2
Committee C-20 on Acoustical Materials, American Society for Testing Materials, ASA Headquarters, New York, N. Y. For information write Fred F. Van Atta, Asst. Sec., A.S.T.M., 1916 Race St., Phila. 3, Pa.

May 9-10
1957 Annual Meeting of the Professional Group on Microwave Theory and Technique, Western Union Auditorium, New York, N. Y.

May 14-16
Second Annual Industrial Nuclear Technology Conference, Museum of Science and Industry, Chicago 16, Ill. For information write Dr. Leonard Reiffel, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

September 9-13
12th Annual ISA Conference & Exhibit, Auditorium, Cleveland, Ohio. For information write William Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.

Bryant magnetic Drums

for semi-permanent storage of data in digital computers or for use as delay lines.

The outstanding performance of Bryant magnetic memory drums is attested to by their purchase by such outstanding companies as General Electric, Radio Corporation of America and Remington Rand.

Designed to your specific requirements, Bryant drums have a guaranteed accuracy of drum runout of .00010" T.I.R. or less. Belt drive or integral motor drive with speeds up to 100,000 R.P.M. or more. Capacities to 5,000,000 or more binary digits.

High Speed Motors, Spindles and Drums

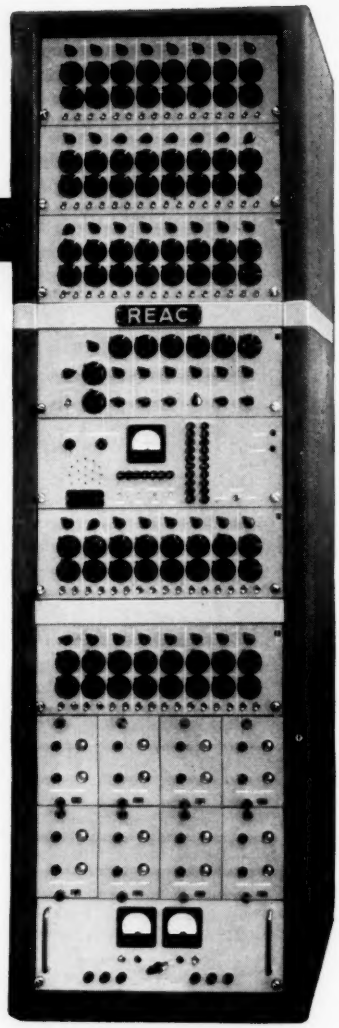
Bryant designs and manufactures electro-mechanical components for precision operation to your requirements, up to 200,000 R.P.M. If you have a problem in applying high speed rotating equipment to your product, write Bryant today.

BRYANT GAGE and SPINDLE DIVISION
P. O. Box 620-I, Springfield, Vermont, U.S.A.
DIVISION OF BRYANT CHUCKING GRINDER CO.

For more information circle **35** on inquiry card.

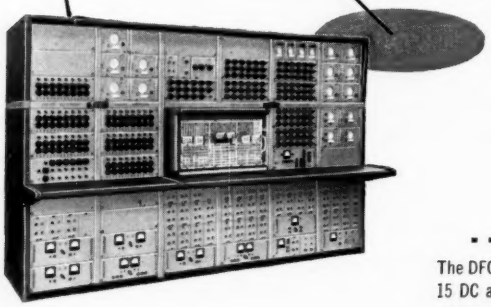
Generation of Functions of *Two or More* Variables

with the 400 series REAC®



DIODE FUNCTION GENERATOR

- Allows direct generation of slopes up to 12 volts/volt without paralleling diode segments.
- 10-turn potentiometers for both "slope" and "break point" give excellent resolution. Still further improvement in resolution is obtained by splitting slope adjustment into two ranges.
- 1000-division direct read-out 10-turn dials permit logging of function for fast reproduction later.
- Flexible switching system allows number of segments per channel to be varied from 2 to 30.
- Built-in calibration circuit permits functions to be set up quickly and easily without use of external plotting board.



See our Booths 1702-1708
I.R.E. SHOW
New York Coliseum
March 18-21, 1957

. . . a complete self-contained unit

The DFG-401 is a completely self-contained unit consisting of 5 channels of function generation, 15 DC amplifiers (with VTVM and all control circuits for monitoring and balancing), and all necessary power supplies (except relay and reference voltages). In the event that any amplifiers supplied are not needed in the problem, they can be made available in groups at the patchbay as inverters with one gain of one.

This unit is ideal for the addition of up-to-date diode function generation equipment to an existing analog computer installation.

Electronic generation of functions of two or more variables is another outstanding Reeves contribution to the flexibility and efficiency of the electronic analog computer. Before installing new equipment, it will pay you to consult us. A comprehensive new REAC "400" series computer technical brochure will be sent upon request.

2RV57

Reeves INSTRUMENT CORPORATION

REEVES INSTRUMENT CORPORATION
A Subsidiary of Dynamics Corp. of America, 225 East 91st St., New York 28, New York

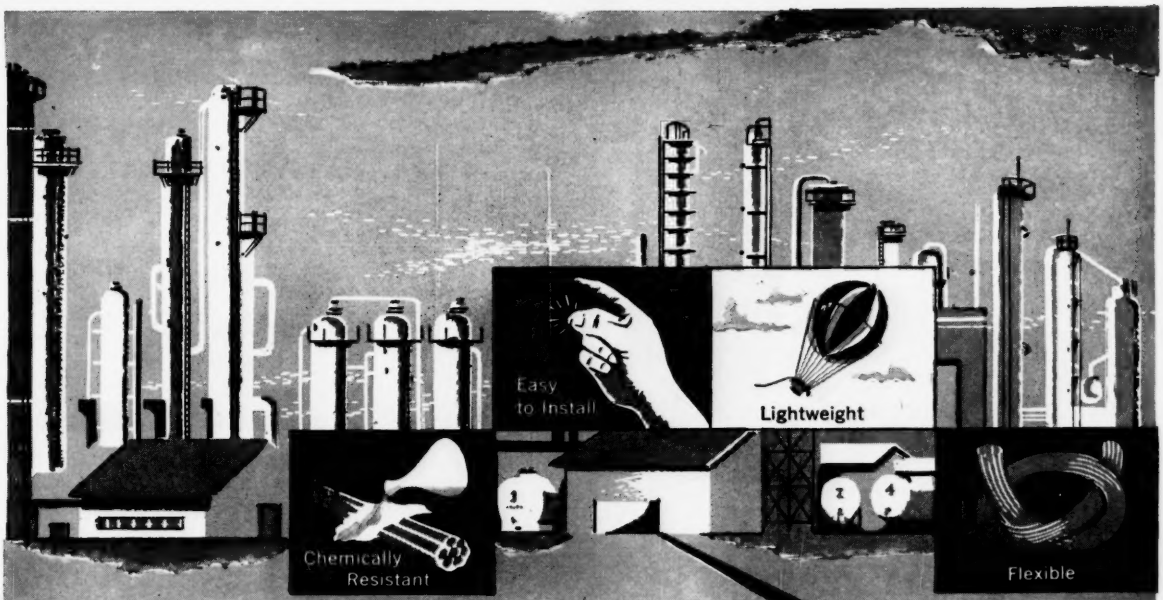
REAC Analog Computers

Precision Floated Gyros

Precision Resolvers and Phase Shifters

Servo Mechanical Parts

For more information circle **36** on inquiry card.



DEKORON

Poly-Cor

harness

Now you can whip high instrument tubing installation and replacement costs in your plant—with Dekoron Poly-Cor®. That's because the chemical resistance of plastic even outlasts expensive alloy tubing . . . because its lighter weight and flexibility make it a snap to install without special tools . . . because you can install practically any number of tubes at one handling, just like electric wiring. You can't lose with Dekoron Poly-Cor — it cuts your investment because of its lower installed cost, cuts your maintenance because it lasts years longer.

Tube up with DEKORON completely

Dekoron products now include single and multiple line metal tubing with plastic coating, multiple tube all-plastic instrument line harness (above), flat 10-tube "ribbon," fittings and junction boxes.

See article on page 464

Dekoron products

QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

AA-1297

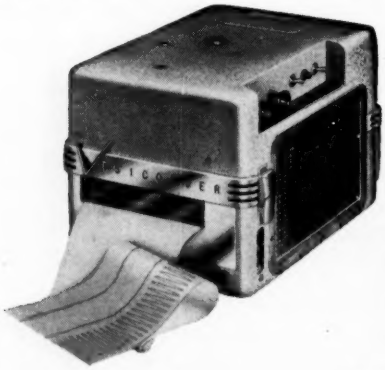
all at once...

the HONEYWELL VISICORDER®

directly records six phenomena at frequencies from DC to 2,000 cps

The versatile Visicorder will fit almost unlimited oscillograph applications where instantaneous monitoring and direct recording at high frequencies are needed.

The Visicorder is the only oscillograph that records directly at frequencies up to 2,000 cps, and at sensitivities comparable to photographic-type oscillographs. No peaked amplifiers or other compensation of any kind are needed. The record requires no liquids, vapors, powder magazines or other processing materials.



Deflection is six inches peak to peak, covering the full width of the chart. The D'Arsonval-movement mirror galvanometers, in your choice of natural frequencies will, of course, overlap their traces; they are not limited by adjacent channels.

Let your nearest Honeywell Industrial Sales Engineer tell you more about how the Visicorder fits *your* application. Call him today.

MINNEAPOLIS **Honeywell**

HEILAND INSTRUMENTS

5200 EAST EVANS AVENUE • DENVER 22, COLORADO

For more information circle **38** on inquiry card.

New Plants and Mergers

GOLDEN-ANDERSON VALVE SPECIALTY CO., Pittsburgh, announces reorganization and expanded facilities with new management group headed by Grant A. Colton as chairman of the board. Mr. Colton will continue in his present capacity as president and general manager.

ALLEN B. DuMONT LABS., INC., announces formation of a new Data and Display Dept. headed by Robert W. Deichert as manager.

GULTON INDUSTRIES announces a new research development and production division for high-frequency telemetering systems and related communications devices in Albuquerque, N.M.

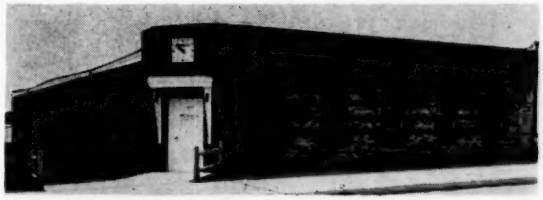
WALKIRT CO. is now established in their new office and plant at 141 W. Hazel St., Inglewood, Calif.

SERVOMECHANISMS, INC., plans construction of a new million-dollar plant in eastern Nassau County to house engineering and production operations of the Subsystems Group.

AMPHENOL ELECTRONICS CORP., Chicago, is celebrating 25 years in electronics manufacturing. In 1932 its sole product was a radio tube socket; today Amphenol makes 25,000 parts.

GENERAL CONTROLS CO., Glendale, Calif., announces merger with Production Instrument Co., Chicago, which will be operated as a separate division.

SHEFFIELD CORP. became a wholly-owned subsidiary of Bendix Aviation Corp. as of Dec. 27, 1956.



PIC DESIGN CORP. has moved to their new plant at 477 Atlantic Ave., East Rockaway, N.Y.

PANELLIT, INC., announces opening of new West Coast manufacturing facilities in Alhambra, Calif., providing sales, engineering and construction services for instrument control centers.

SERVO CORP. OF AMERICA announces appointments of Dave Gilbertson Co. as sales representative in Minnesota and Western Wisconsin, and Russell F. Clark Co., Pittsburgh, for West Virginia and Western Pa.

C. P. CLARE & CO., Chicago, announces new field engineering and sales office at 6047 Hollywood Blvd., Los Angeles, with Jesse R. Stone in charge.

...power, average stress

...energy

...distance

...quantity, average pressure

...impulse, velocity

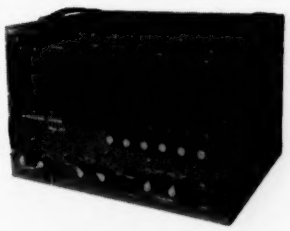
ALINCO's *Model 270 electronic*

INTEGRATING SYSTEM

for studies of transient phenomena

THE all-electronic Model 270 is designed for use in dynamics and statistical quality control to automatically compute the time integral of any analog signal. Its counting rate of 10,000 counts per second permits stable, accurate measurements as short as 10 milliseconds in duration. Counting begins by preset signal level or by closing contacts, and stops by signal decay or by preset time (in increments of 0.0001 sec.). Both time and total integral are displayed on digital counters, and the instrument saves time while increasing accuracy by eliminating manual computation. Write for detailed literature on this field-proven instrument.

ALLEGANY INSTRUMENT COMPANY, INC.
EASTERN DIVISION: 1091 WILLS MOUNTAIN, CUMBERLAND, MARYLAND
WESTERN DIVISION: 1052 WEST 6TH STREET, LOS ANGELES 17, CAL.

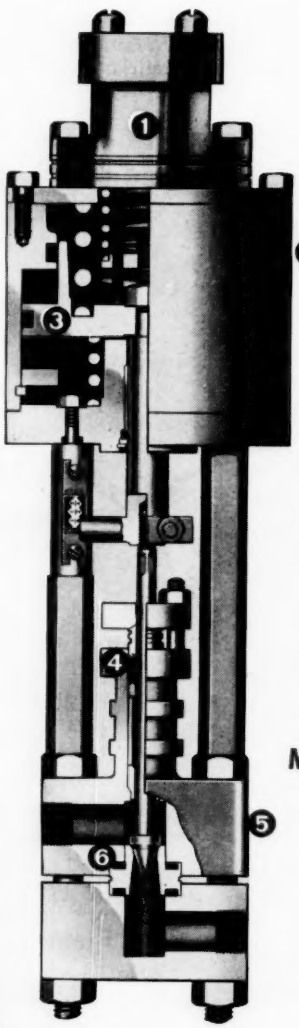


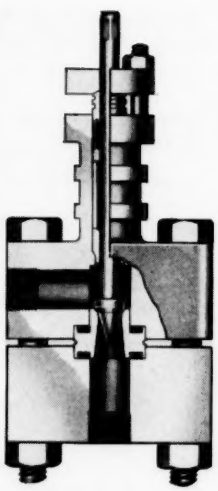
For more information circle **39** on inquiry card.

Split second action ...small flow control ...at 6,000 psi

New achievement by Annin in high pressure control and precise valve response for Research–Development–Process applications

Annin's new Model 9460, designed for working pressures to 6,000 psi, provides research, pilot plant and process control engineers with an extremely responsive small flow control valve suitable for low capacity systems. The operator will fully stroke in either direction in 0.75 seconds or less. New design features include: ❶ integral positioner, open-on-air-failure or close-on-air-failure action; ❷ Annin's 600 Series Domotor operator; ❸ differential area piston, eliminating need for loading regulator; ❹ universal stuffing box for −400°F to 750°F; ❺ offset globe or angle body design; ❻ valve plug stem and seat ring common to both globe and angle bodies. For reliable fluid control and flexibility of application Annin offers the *best source* for solving any small flow control problem.



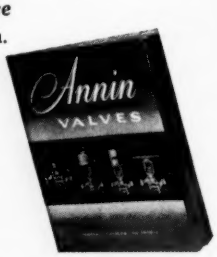


Model 9461 *angle body*

Angle bodies are available with body sections rotatable in 90° increments for piping convenience.

YOURS FOR THE ASKING—

Complete information and specifications are contained in Bulletin No. 9400. Write for your copy today.

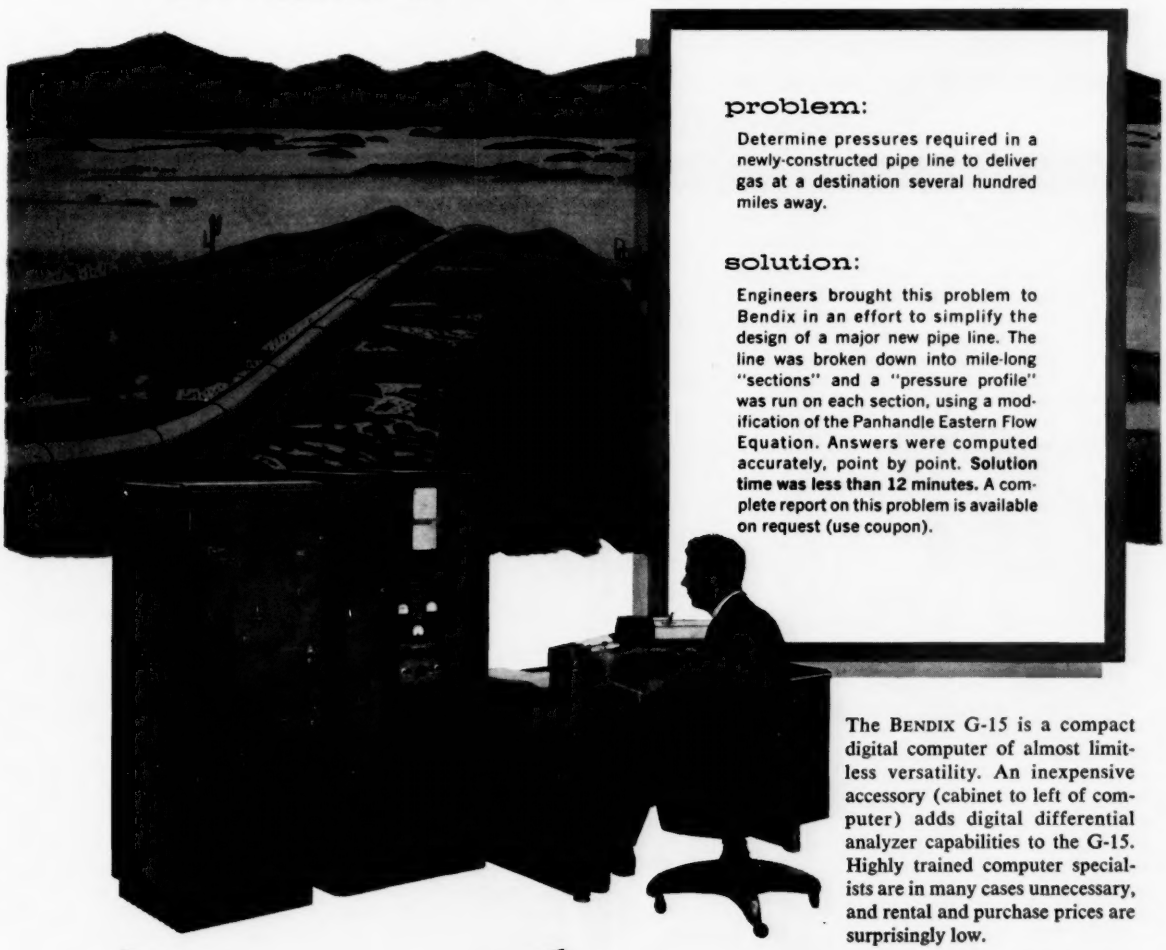


ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

For more information circle **40** on inquiry card.

a Bendix Computer simplifies cross-country pipe line construction



problem:

Determine pressures required in a newly-constructed pipe line to deliver gas at a destination several hundred miles away.

solution:

Engineers brought this problem to Bendix in an effort to simplify the design of a major new pipe line. The line was broken down into mile-long "sections" and a "pressure profile" was run on each section, using a modification of the Panhandle Eastern Flow Equation. Answers were computed accurately, point by point. **Solution time was less than 12 minutes.** A complete report on this problem is available on request (use coupon).

The BENDIX G-15 is a compact digital computer of almost limitless versatility. An inexpensive accessory (cabinet to left of computer) adds digital differential analyzer capabilities to the G-15. Highly trained computer specialists are in many cases unnecessary, and rental and purchase prices are surprisingly low.

Bendix Computer

DIVISION of BENDIX AVIATION CORPORATION
5630 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA
OFFICES IN WASHINGTON, D.C., DALLAS, LOS ANGELES AND CHICAGO

Export Representatives
Computing Devices of Canada, P. O. Box 508, Ottawa 4, Ontario
Bendix International Division, 205 E. 42nd Street, New York 17, N.Y.

BENDIX COMPUTER DIVISION—BENDIX AVIATION CORPORATION
5630 ARBOR VITAE STREET, LOS ANGELES 45, CALIFORNIA

Please send me more details on Model G-15 General Purpose Digital Computers, and include a copy of the pipe line report.

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

For more information circle **41** on inquiry card.

Immediate Delivery...

on Mallory Silver Rivet Contacts

Mallory Silver Rivet Contacts are standardized in 70 stock types and sizes—which means you can count on immediate delivery for pilot run or production.

Mallory's standardization program was built on the results of an intensive study of thousands of silver rivet contact orders. From this survey, 70 basic types were evolved to fit the great majority of applications specified in these orders.

Availability from stock means time saved on orders. Standardization means a wide selection of catalog items, often providing an in-stock item for what might otherwise have been a specially tooled job with its associated higher cost and longer wait.

Dimensions, part numbers, ordering information and pricing data are included in the Mallory folder on silver rivet contacts. Before you place a specially tooled rivet order, why not check the Mallory list for a stock item—and tally up added cost savings on your next production run? Write—or ask the Mallory representative for your copy of Bulletin 3-15A.

IF ... your requirements are unusual, and do call for special contacts—Mallory engineers will be glad to assist in designing and specifying—Mallory production facilities are available for contacts or complete contact assemblies.

Expect more... get more from

Serving Industry with These Products:

Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical — Contacts • Special Metals • Welding Materials

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

For more information circle **42** on inquiry card.

People IN THE NEWS

VICTOREEN INSTRUMENT CO. announces election of *Raymond F. Shima* as executive vice president and general manager.

R. F. Shima

J. R. Simpson

CONOFLOW CORP. announces appointment of *J. Robert Simpson, III*, as sales manager.

LOGISTICS RESEARCH INC. has named *Andrew T. Fischer* marketing director.

A. T. Fischer

Eric Weiss

DAYSTROM SYSTEMS DIV., Daystrom, Inc., announces *Eric Weiss*, an authority on computer design, has joined the engineering staff.

ISA announces that *Lloyd Slater* has been named executive director of the Foundation for Instrumentation Education and Research. Initial project of the foundation will be to "survey needs for technical manpower in the instrumentation-automation field and to create a list of projects to meet this initial need."

Obituaries

DONALD P. CAMPBELL, consultant and authority on servomechanism and control problems, died at the age of only 38, on Jan. 15, 1957, a victim of a heart attack. For 16 years, Don was on the staff of the Electrical Engineering Department of MIT. The finest tribute we can pay to our friend Don Campbell is to refer all our readers to his classic book, *Principles of Servomechanisms*, G. S. Brown and D. P. Campbell, Wiley, 1948.

JOSEPH F. JOY, founder of Joy Mfg. Co., passed away on February 19, 1957, at the age of 73. Mr. Joy owned hundreds of patents and his name became synonomous with mechanized mining equipment.

IRA EMMET McCABE, Chief Engineer and Chairman of the Board of the Mercoid Corp., died February 13, 1957.

E. W. BAIRD, JR., president of T. J. Cope, Inc., died of pneumonia on Jan. 15 at his Bermuda home.

PERFORM EXTENDED PORE-STRUCTURE ANALYSES

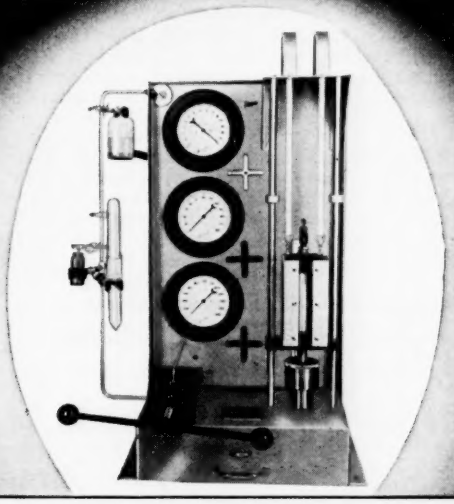
Quickly-Accurately-Safely

with AMINCO - WINSLOW

POROSIMETER

This instrument provides data on the distribution of porosity over the range of pore diameters from 0.1 to 0.00006 millimeters. A specially designed penetrometer allows detection of changes in pore volume as small as 0.0005 cc. Such information is invaluable in the critical evaluation and selection of various materials such as sintered metals — plastics — chemicals — textiles — building materials — catalysts — absorbents — soils.

Instrument operates on the mercury-intrusion principle with a sample less than 1 cc in size. Device is completely hydraulic (gas free). Pressure is applied by a hand-operated pressure generator. No operational hazards are present. Cat. No. 5-7105 Porosimeter, complete as illustrated with instructions, filling device, and two penetrometers for different types of samples. Maximum operating pressure: 3000 p.s.i...$1900



Complete details furnished in **Bulletin 2282—P**

AMERICAN INSTRUMENT CO., INC.

Silver Spring, Md. in Metropolitan Washington, D. C.

For more information circle **43** on inquiry card.

MICROAMMETER-MILLIVOLTMETER RECORDER PERFORMS 6 FUNCTIONS

1. **Measures low-level dc signals with calibration accuracy within 0.5%, and sensitivity within 0.2% of span.**
2. **Records on 3" continuous strip chart or IBM-type card chart, with linear coordinates.**
3. **Positions recording pen with force many thousand times greater than usual direct-deflection electrical movements.**
4. **Operates on force-balance principle—compensates for ambient conditions, changes in power supply and components.**
5. **Records fast—up to 0.05 seconds for 63% of fullscale changes.**
6. **Provides span and zero adjustments for easy calibration and zero suppression in the field, without special equipment.**

Here's How To Get POSITIVE, ACCURATE Records of Electrical Measurements ALL THE TIME...

This highly sensitive 'American-Microsen' Series 130 Recorder, with all its operational advantages, costs less than others designed for the same jobs. Simple design, precision components and rugged construction assure sustained high accuracy and freedom from maintenance. The recorder withstands shock up to 30 times gravity.

Since its introduction less than a year ago, the Series 130 Recorder has been very successful because it offers a more accurate and durable method of recording dc electrical signals at lower cost. It is being used to record outputs of many different electrical transducers—for measurement of such variables as pH, gas analysis, signal strength and others.

Many laboratories have adapted the Series 130 Recorder to their analytical and scientific instruments to assure accurate, permanent records of results which previously were only indicated. The Recorder can be used with any device which can provide 200 microamperes or more in its output circuit.

Standard 'American-Microsen' Series 130 Recorders are priced at $250.00. All models have ample power to operate alarm contacts which can be supplied at extra cost. *Write for Bulletin MG10.*

SPECIFICATION BRIEFS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts.
INPUT RANGES: Voltage – 0-20 millivolts to 0-100 volts dc. **Current** – 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** – 6700 ohms per volts.
ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span. **REPEATABILITY:** ± 0.25% of span.
EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.
EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.
RESPONSE TIME: Fast Speed – 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed**– approximately 4 times fast speed setting.
CHART SPEEDS: Strip Chart – 1" per hr., standard; 3" or 6" per hr. available. **Card Chart** – 1 rotation per day, standard.
SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.
PANEL SPACE REQUIRED: Only 27 square inches.

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

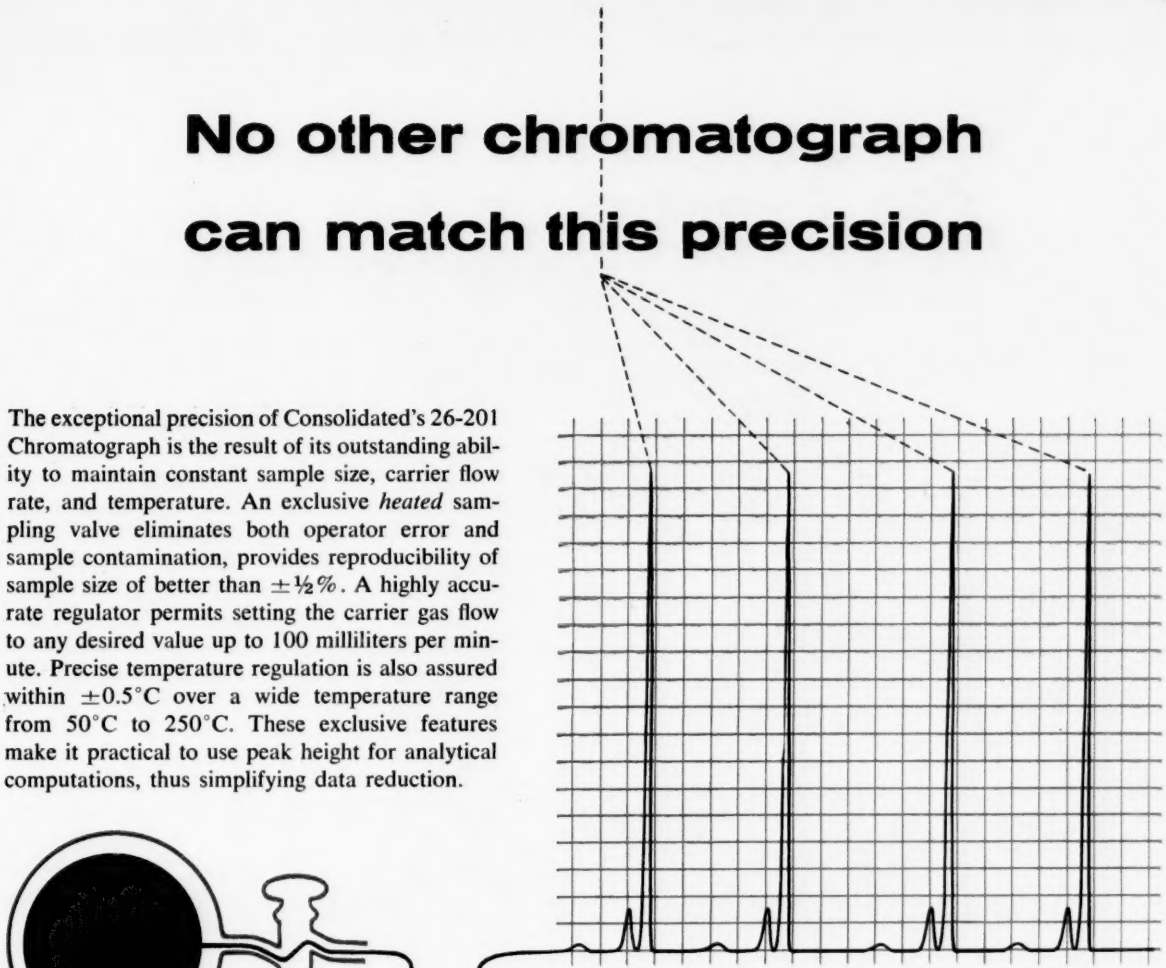
INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATORS, RECORDERS, CONTROLLERS, ELECTRO-PNEUMATIC VALVE POSITIONERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

For more information circle **190** on inquiry card.

No other chromatograph can match this precision

The exceptional precision of Consolidated's 26-201 Chromatograph is the result of its outstanding ability to maintain constant sample size, carrier flow rate, and temperature. An exclusive *heated* sampling valve eliminates both operator error and sample contamination, provides reproducibility of sample size of better than ±½%. A highly accurate regulator permits setting the carrier gas flow to any desired value up to 100 milliliters per minute. Precise temperature regulation is also assured within ±0.5°C over a wide temperature range from 50°C to 250°C. These exclusive features make it practical to use peak height for analytical computations, thus simplifying data reduction.



SUPERIOR REPRODUCIBILITY... The four sample runs of natural gas illustrated above prove the outstanding reproducibility of the Consolidated Chromatograph. Time: 6 minutes. You get fast, accurate analysis of almost any mixture, including liquids with boiling points as high as 325° C.

CEC'S VAPOR PHASE CHROMATOGRAPH

Operates with either adsorption, gas-liquid partition, or reaction columns. Microsampling makes the instrument practical for all types of laboratories. Contact your nearby CEC field office, or write for Bulletin CEC 1831-X20.

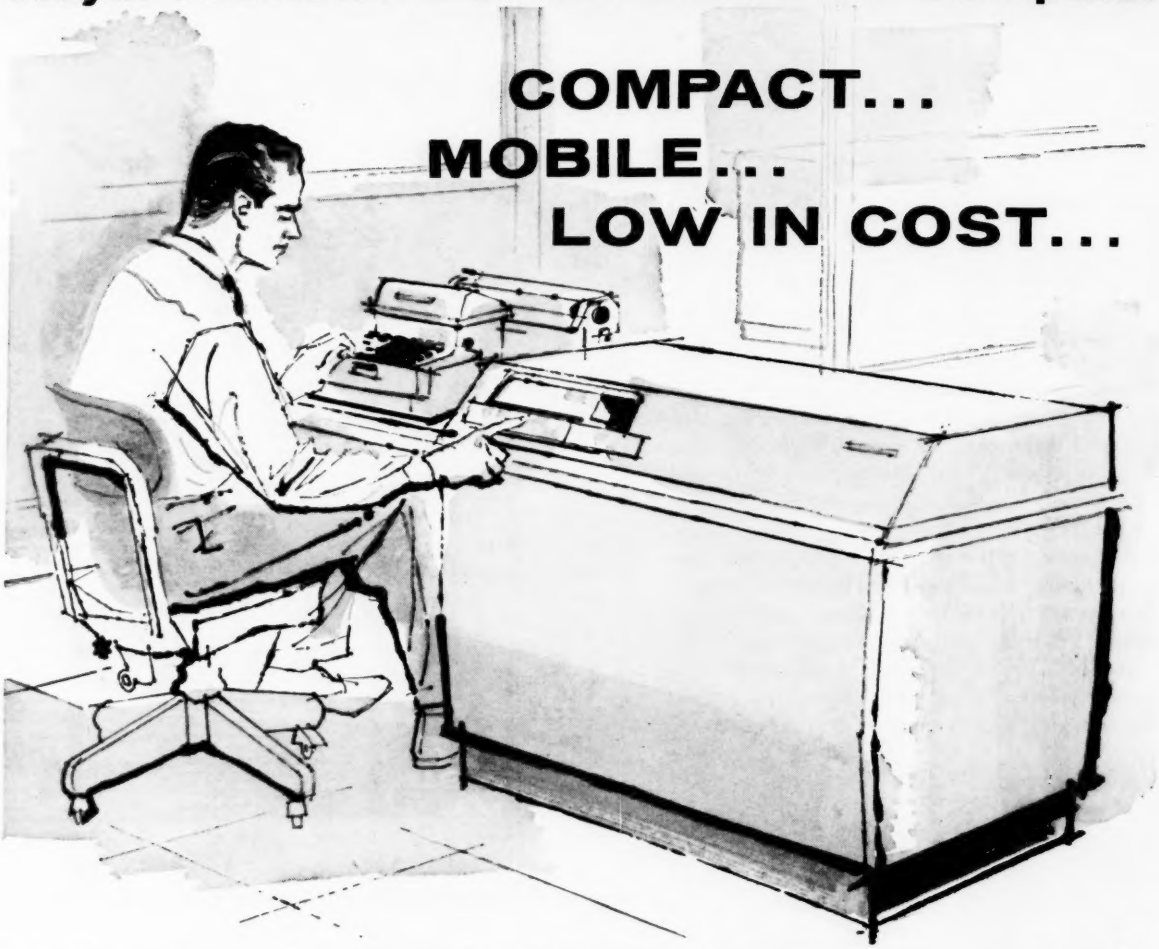
Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

NATIONWIDE COMPANY-OWNED SALES & SERVICE OFFICES

For more information circle **68** on inquiry card.

Royal Precision LGP-30 Electronic Computer



high-speed computation right at your desk

The result of 20 years' experience in the design of electronic computers, LGP-30 puts you in complete control of your own engineering problems. Used right at your desk, LGP-30 allows you to program your own material without planning in detail. You modify equations on the spot, follow your work to completion. Thus, you eliminate much detailed calculation . . . uncover added time for creative engineering.

Ease of operation. LGP-30's simple command structure offers the same complete internal programming found in computers many times its size and cost. Internally binary, serial, single address . . . LGP-30 enters and reports alpha-numeric information by punched paper tape or keyboard.

Greatest capacity in price range. The most powerful stored program computer of its size yet developed, LGP-30 has a magnetic drum "memory" of 4096 words. Fully automatic, it performs sub-routines . . . executes self-modifying programs.

Exceptional flexibility. LGP-30's wide range of applications includes double precision abstractions; compiling and diagnostic routines; 3-address interpretive routine with floating point abstractions; matrix operations including inverting and Eigen value problems; basic trigonometry and log functions; square root and roots of polynomials.

Nation-wide sales and service. Detailed analysis of your requirements is available through Royal McBee's nation-wide staff of trained applications engineers.

Outstanding features of LGP-30

- **Operates from regular wall outlet (110 volts AC).**
- **No expensive installation . . . no external air conditioning.**
- **Unusually large "memory"— 4096 words.**
- **Word length: 32 bits, including sign and spacer bit.**
- **Average access time: 8.5 ms.**
- **Optimum access time: 2 ms.**
- **Lowest cost ever for a "complete" computer.**
- **Nation-wide sales and service.**

For further information, write Royal McBee Corporation, Data Processing Equipment Division, Port Chester, N. Y.

ROYAL McBEE
CORPORATION
ROYAL TYPEWRITERS • McBEE BUSINESS SYSTEMS

For more information circle **44** on inquiry card.

Circle **46** on inquiry card. ⟶

For quickest service in solenoid valves, write for Skinner's Nationwide Stock List

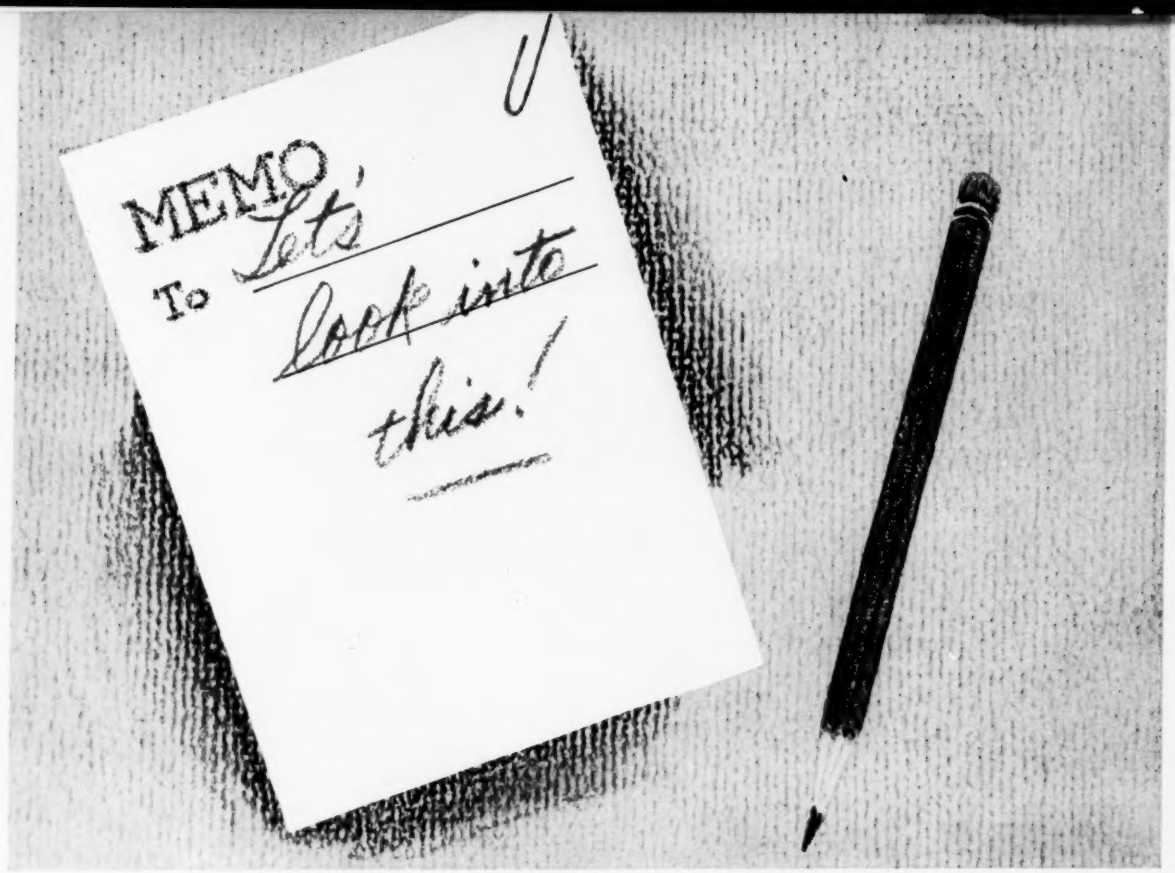
The Skinner Nationwide Stock List covers the most universally applied Skinner Solenoid Valves for air and hydraulic service. All the valves listed are carried by every Skinner Stocking Distributor in the U. S. From his stock, your own local distributor can quickly meet your requirements. So for your own convenience, we urge you to write for this nationwide stock list of Skinner Solenoid Valves.

Skinner Stocking Distributors are located in all key industrial areas. If you have a solenoid valve problem, talk to the one nearest you. Tell him your requirements in regard to port sizes and locations, voltages, pressures, temperature conditions, capacities and mountings. Let him show you how easily he can select the valve you need.

For complete information on Skinner's line of exceptionally long-life 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 413.

Skinner Solenoid Valves are distributed nationally

SKINNER ELECTRIC VALVE DIVISION NEW BRITAIN CONNECTICUT



SALES MANAGERS: You route this memo—

to your ad department and agency—reminding them to plan now to advertise in the 1958 I&A Handbook & Buyers' Guide

Industry's only instrument-control equipment buying directory, the Guide offers you . . .

- Entree to 23,000 buyers of instrument and automatic control equipment.
- A directory listing equipment, names and addresses of 3,000 manufacturers.
- Twenty-two years experience selling to OEM and end users.
- Year 'round contact with industry's big buyers.

Reserve your ad space now. Forms close August 15-31—write:

INSTRUMENTS PUBLISHING CO., INC.
845 Ridge Ave., Pittsburgh 12, Pa., FAirfax 1-0161

Eardrums can sometimes double as pressure gages . . . BUT

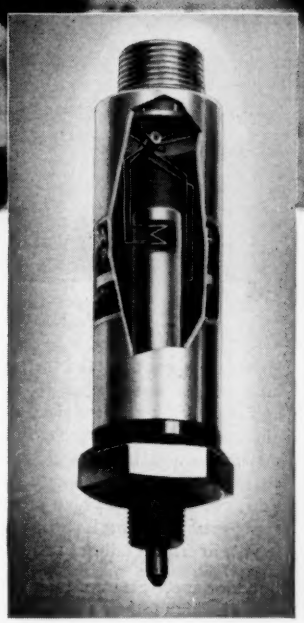
Use SR-4® Fluid Pressure Cells to measure and control all industrial pressures . . . safe, rugged, accurate to ± ¼%

The skin diver's eardrums are a kind of "go no-go" gage that tells him when he's down as far as he can go. But popping eardrums aren't recommended for performing accurate industrial pressure measurements!

SR-4 Fluid Pressure Cells will measure absolute or differential pressures consistently to less than ± ¼% accuracy! Using well-known SR-4 Bonded Wire Strain Gages, these transducers convert pressure changes directly into a varying electrical signal. This signal can be fed to Baldwin indicators, recorders, controllers or other instruments in a system. There are no moving parts to wear out, no long pressure lines with possible leakage and fire hazards. Remember, a system is only as accurate as its transducer.

If you have pressure measurement problems, a B-L-H representative will be happy to help you—in selecting the proper transducer or in engineering a complete pressure measuring system.

Write today to Dept. A for your free copy of Bulletin 4306, showing the wide range of SR-4 Fluid Pressure Cells.



SR-4 Fluid Pressure Cells are made in standard units with capacities as low as 15 psi and as high as 50,000. With pressure converted to proportional electrical voltage, the instruments for reading changes may be located at any remote point.

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

SR-4® strain gages • Transducers • Testing machines

BALDWIN BLH LIMA-HAMILTON

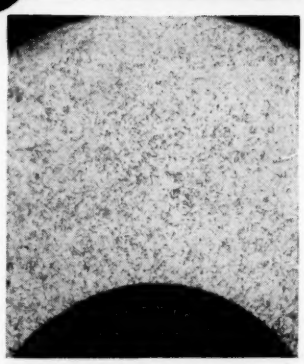
For more information circle 47 on inquiry card.

Super-Pressure Tubing—Economical and Dependable for pressures as high as 100,000 PSI

Here's how *you* can take the high cost out of high-pressure installations. No more machining and deep-drilling of stainless steel bar—that's old fashioned and expensive. For high-pressure autoclaves and in research labs where pilot equipment for hydrogenation and polymerization processes require high pressures, Superior super-pressure tubing is cutting high costs, helping avoid critical failures and downtime.

Superior super-pressure tubing offers long service life, high fatigue strength, excellent corrosion and chemical resistance. Available in single wall or composite wall (shown above), it is designed to carry internal pressures ranging from 15,000 to 100,000 psi, in OD sizes ranging from .125 in. to .750 in. Primary advantages of single wall tubing are economy and reliable service, plus long life, at recommended maximum working pressure for a given size. Composite wall tubing, used for extra-high pressures, offers the advantages of combining different materials. For example, the inner wall can be highly corrosion resistant, while the outer wall, not exposed to such corrosion, can be of a more economical material. Analyses for Superior super-pressure tubing include stainless steel Types 304, 316, 321 and 347 and AISI 4130 alloy steel.

Why not call on our long practical experience with super-pressure tubing. We can help you with virtually any tubing problem that confronts you. For more super-pressure tubing information, get your free copy of Data Memo 22. Write Superior Tube Company, 1968 Germantown Avenue, Norristown, Pa.



Unretouched photomicrograph shows etched section of Type 304 stainless steel super-pressure tubing at a magnification of 50x. Note smooth, uniform ID and fine grain structure.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to ⅝" OD—certain analyses in light walls up to 2½" OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

For more information circle **48** on inquiry card.

Automatic Parking—P.D.Q. Style

Panhandle Pete

"FLASH!!!" My eyes winced as I stared at this word, splashed across the top of another advertising blurb from the Wallace Electronic Service Company, New Somerset, Jefferson County, Ohio and only recently left at my home by Uncle Sam. Printed in large, shaky, fire-engine-red letters, this notice from the Gods was followed by the phrases "Are you unhappy in this automated era?" "Do you take more than your share of aspirin and sleeping pills?" "Is our life just one long search for a parking place?"

"My gosh," I thought to myself, "Is Wallace starting to sell kidney pills now?" So I read on, hoping to find more information in the forest of exclamation points and question marks. (By the way, did you read Milton H. Aronson's column Q.E.D. in the December 1956 *Instruments and Automation* without shedding a tear? Among other things Milton did not editorialize on was the obvious fact that this magazine is the only one in the field with a humorist on the staff—two of us; we have a cartoonist too!) But my eyes gave out on the brilliant display of red, green, purple and yellow inks which covered the ad and so I drove over to see the Chief Engineer of the company, John L. (Bus) Wallace, at his office.

"Yeah," he said, "We've really hit on something good this time! There's lots of people who thought we were just full of gas when we introduced our "Aves" gas analyzer on the market, and a lot of scoffers came around to see or wrote in for catalogs and found out we had an instrument they needed. As you can see from this list of startled customers, we're doing fine with that line. Now the latest development is something for which the world has waited fifty years. Our "Par-Kometer Model P(D)Q is going to solve all the . . ."

"Wait a minute. What is a Par-Kometer?" I asked John L. "Tell me all about it. I'm sure the readers of *Instruments And Automation* will be interested in such a, as you call it, world-shaking development. Besides, our *Instruments And Automation* advertising is more sightly and couth than this—and I waved it under his nose—so-called 'Flash!!!' of yours."

"Oh that," he says, "That's one of our Sales Manager's ideas. 'Yuh gotta hittem in the eye and mak'em read your stuff, Cuz,' hesays. 'Sometimes I wonder about Waldo Klapsaddle and his ideas. But what the heck! We're selling instruments with them."

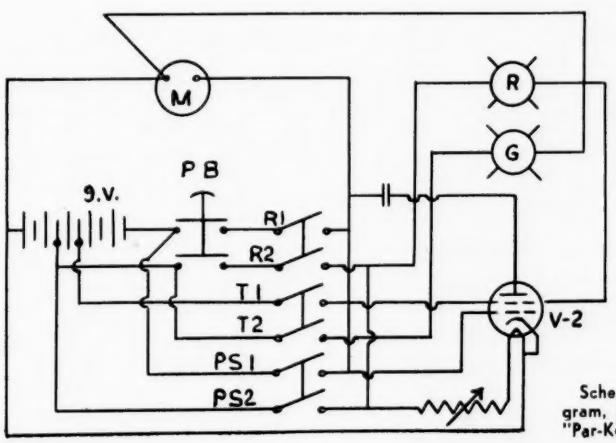
"The Par-Kometer? Listen, have you been aware of the fact that everyday the ratio between the number of automobiles and the area left in the world on which to park them becomes less and less, following the law of Buckingham's Exponential Extrusion? You didn't? Why my wife has worn out three clutches in my little Hudson just in Steubenville alone. At the mill, unless you are one of the brass, parking is *non est*. All over the country—I'll even go so far as to say over the world—people are frantically dashing around hunting a dime to put in the pay—uh, no. We're working on *this* problem too. Anyhow, it is impossible to find a parking spot and after our Herr Doktor Alles collected 1051 parking tickets, paid $2210.52 in court fees fighting the parking meter racket and finally lost his car and drivers license, he spent his time in jail thinking over the problem and thank goodness, came up with a solution."

"Here," and John L. reached and pulled out a little black box, "Here is the answer to the world's traffic jams, jangled nerves, loss of religion, fines . . . you name it. As you can see, this box has a carrying strap, an indicator, a Chicago Key, two lights, some hose and a squeeze bulb. All you have to do is take this box, step out of your car, squeeze the bulb and look intelligent. We furnish two instruction books with the instrument; One is 'How to Park Your Car' and the other is 'How to Look Intelligent.' And it sells for only $123.46 in the Standard model up to $416.32 for the Delux model. The main difference is that the Delux model has the ubiquitous vacuum tube in it for people who like vacuum tubes. How many do you want?"

"Now hold on a minute. Whose leg are you trying to pull? I wasn't born yesterday and I don't see how . . ."

"Well relax, boy, it works. We have tried it out at the mill and in the second largest city in West Virginia. Like I said before, all you do is be sure someone in authority is looking, then squeeze the bulb, wait till the meter reads 100% and the red light lights and then say, 'Tsk! tsk! tsk! this looks bad', with pursed lips and a shake of the head. When you do this, the onlookers will immediately move their vehicles, leaving lots of space for you. It works 92% of the time at present. Of course our research department is working on ways to increase this efficiency. We furnish a set of calibrated scales for the meter which we will make in any units you like such as % Gas/sq. ft. Sewer Gas/per mile/inch diameters. A new one we have is 'Geigers per sq. cm.' If you have trouble finding seats in restaurants we have one 'Cockroaches per running foot.' There just isn't any limit to what we can calibrate the meter for!"

"Here, I'll give you a wiring diagram of the Par-Kometer, two instruction books and you think about it."—*Panhandle Pete*



Schematic wiring diagram, Model P (D) Q "Par-Kometer."

NEW
high level performance
pressure transducers

by BOURNS

- *High vibration performance*
- *Temperature compensation*
- *Expanded measurement ranges*
- *High reliability*

An entirely new concept in pressure instrument performance combined with Bourns' experience in fine instrument manufacturing.

MODEL 409
Absolute Pressure Transducer

. . . a new design which provides extremely accurate performance characteristics. An advanced mechanism results in low vibration sensitivity for high vibration levels over all pressure ranges.
Temperature compensation and optimum material selection result in negligible temperature effect over a wide temperature environment.
Available ranges: 0-2 psia to 0-100 psia.

Write for Bulletin 409

MODEL 509
Differential Pressure Transducer

. . . a new design with the same *quality plus* features as the Model 409. The diaphragm capsules manufactured by Bourns provide exceptional hysteresis and linearity performance in addition to the low temperature error. These production instruments are assembled and tested to exacting quality standards.
Available ranges: 0-2 psi to 0-100 psi.

Write for Bulletin 509

COPR. BL

BOURNS LABORATORIES, INC.
General Offices: 6135 Magnolia Ave., Riverside, Calif.
Plants: Riverside, California—Ames, Iowa

TRIMPOT ® LINEAR MOTION POTENTIOMETERS • PRESSURE TRANSDUCERS AND ACCELEROMETERS

For more information circle **49** on inquiry card.

Books

Computers; Their Operation and Applications, by Edmund Callis Berkeley and Lawrence Wainwright. [c1956.] Reinhold Publishing Corp., New York 22, N. Y. 366p. $8. 9 in. Discusses chiefly automatic computing machines of the digital and analog types. Includes information on miniature computers and on some large-scale machines, and has a section on application with brief attention to military applications. Gives a list of manufacturers and a list of organizations offering automatic computing services. Includes a glossary.

Basics of Phototubes and Photocells, by David Mark. [c1956.] John F. Rider, New York 13, N. Y. 128p., unbound. $2.90. 8½ in. Purpose is to give principles, techniques, circuits, and practical applications of photoelectricity. Prepared for readers with fundamental knowledge of basic electronics.

Atoms and Energy, by H. S. W. Massey. [1956.] Philosophical Library, New York 16, N. Y. 174p. $4.75. 8½ in. A non-technical account of the developments in atomic physics which led up to the large-scale release of atomic energy. Discusses peaceful and military applications of atomic energy. Written with unusual clarity.

Advances in Electronics and Electron Physics, v.7, edited by L. Marton. 1955. Academic Press, New York 10, N. Y. 527p. $11.50. 9¼ in. Lengthy papers from various research laboratories. Includes physics of semiconductor materials, electrical properties of germanium and silicon, energy losses of electrons in solids, sputtering by ion bombardment, radio astronomy, analog computers, and electrical discharge in gases.

Automatic Digital Computers, by M. V. Wilkes. 1956. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 305 p. $7. Introduces principles underlying the design and use of digital computers, including logical design and programming.—Illustrated by detailed descriptions of a few machines. Level is undergraduate.

Best Value in all-purpose scopes

WESTON OSCILLOSCOPE

- identical vertical and horizontal amplifiers, D-C and A-C coupled.
- 4.5 mc band width (for color)
- 15 mv sensitivity
- normal or flat faced tubes (high intensity)
- Z-axis modulation
- 3X horizontal sweep expansion
- identical phase shift to 1 mc—can be adjusted up to 6 mc
- etched circuit construction
- ease of calibration
- polarity reversal switch
- only **$395.50** (with flat faced tube $430.50)

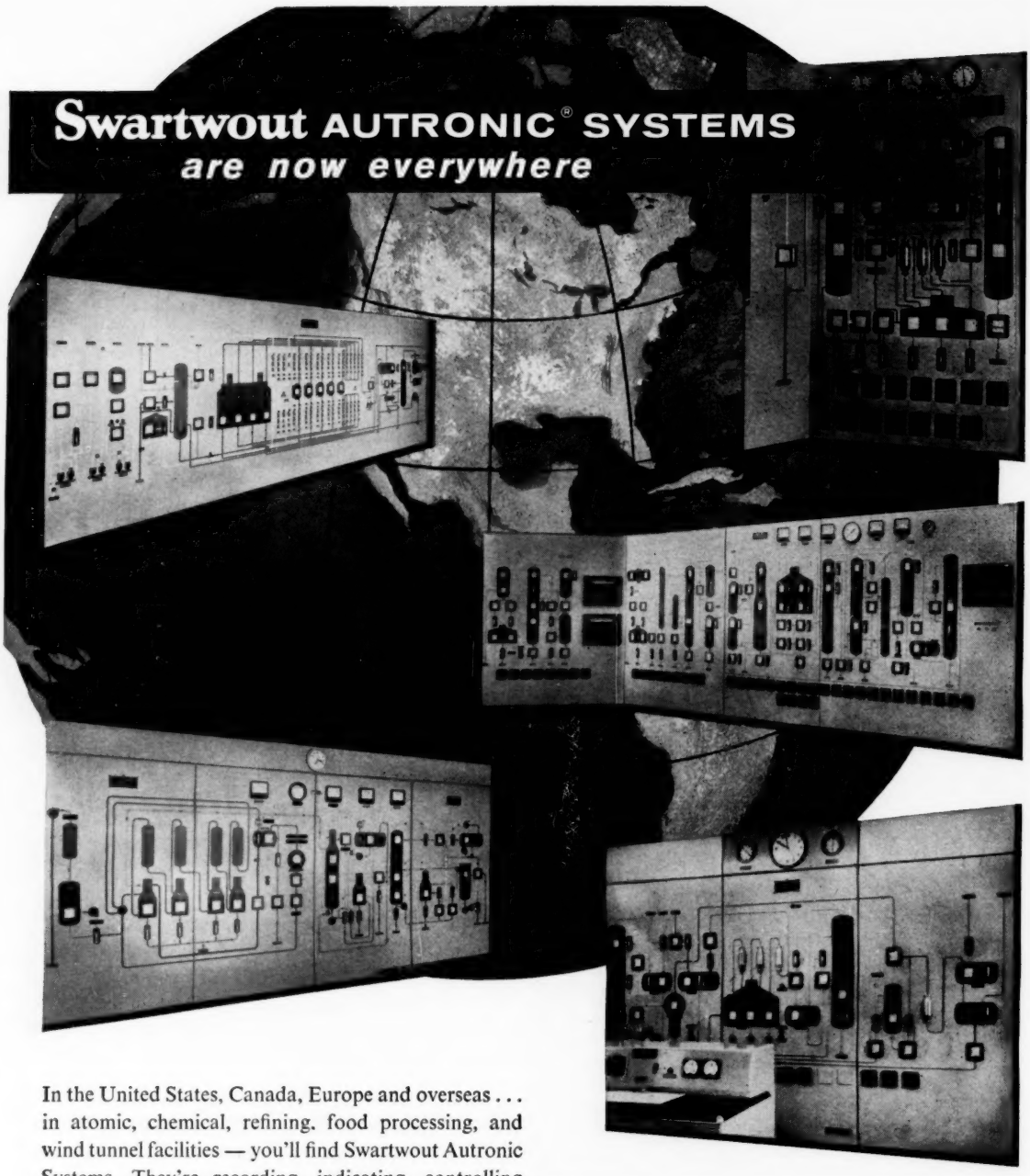
WESTON Oscilloscopes, and other Weston test equipment, are available through local distributors. For complete information, write Weston Electrical Instrument Corp., Newark 12, N. J.—A subsidiary of Daystrom, Incorporated.

A DAYSTROM UNIT

WESTON *Instruments*

For more information circle **56** on inquiry card.

Swartwout AUTRONIC® SYSTEMS
are now everywhere



In the United States, Canada, Europe and overseas . . . in atomic, chemical, refining, food processing, and wind tunnel facilities — you'll find Swartwout Autronic Systems. They're recording, indicating, controlling processes just like yours. And they're doing it all-electronically — faster, more accurately, more economically. *You'll go all-electronic eventually — go Autronic now with Swartwout, pioneer and leader in miniature electronic controls.* AA-4928

ENGINEERING CAREERS AVAILABLE

Not just a "job," but a lifetime career awaits creative electronic and mechanical engineers. You'll work on long range projects with the pioneer and leader in the field. Write in confidence to Engineering Personnel Manager.

Swartwout *Autronic®* **CONTROL SYSTEM**

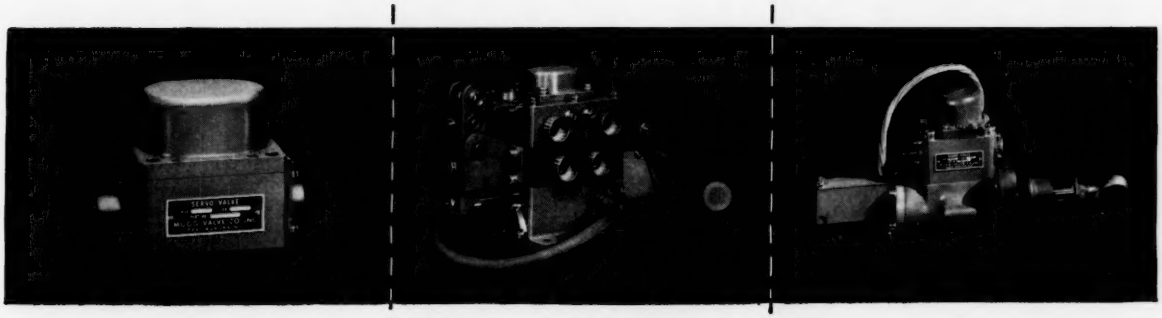
THE SWARTWOUT COMPANY • 18511 EUCLID AVENUE • CLEVELAND 12, OHIO

For more information circle **51** on inquiry card.

From MOOG . . . **Advanced Electro-Hydraulic Servo Components**

Moog is the industry's leading producer of electro-hydraulic servo valves. This leadership has been achieved by advanced valve design resulting in high performance, high quality, reliability and efficient manufacture. The same creative approach applied to industry's newer problems has resulted in the introduction of Moog Dual Input and Servo Actuator units.

These recent achievements in the creation of advanced custom designed electro-hydraulic servo components are evidence of Moog's continuing progress.



SERVO VALVE

• These proportional "dry motor" electro-hydraulic servo valves feature high dynamic response, sensitivity, linearity and reliability. Light-weight and compact, they are also available in custom designed versions for special or advanced applications.

DUAL INPUT SERVO VALVE

• This new component provides for positioning of aircraft control surfaces by summing mechanical and electrical inputs without external use of mechanical linkages. Use of an entirely new concept offers improved performance, system simplification and saving of space and weight.

SERVO ACTUATOR UNIT

• Custom designed integrated assemblies include actuating cylinder, electro-hydraulic servo valve and feedback sensing device. In a closed loop, actuator displacement is a function of input signal.

TO THE ENGINEER IN A "HURRY"

Axiomatically, to get somewhere in a hurry, you get aboard something that moves pretty fast.

If your "somewhere" is a career in engineering, consider Moog. From three founders to five hundred employees within five years, we are today the industry's leading manufacturer of advanced electro-hydraulic servo components. Our engineers made this possible by continuous pioneering of the new and successful developments in the field. As our rapid expansion continues, we have many openings at all levels for qualified personnel.

Best time to get aboard is now.

MOOG

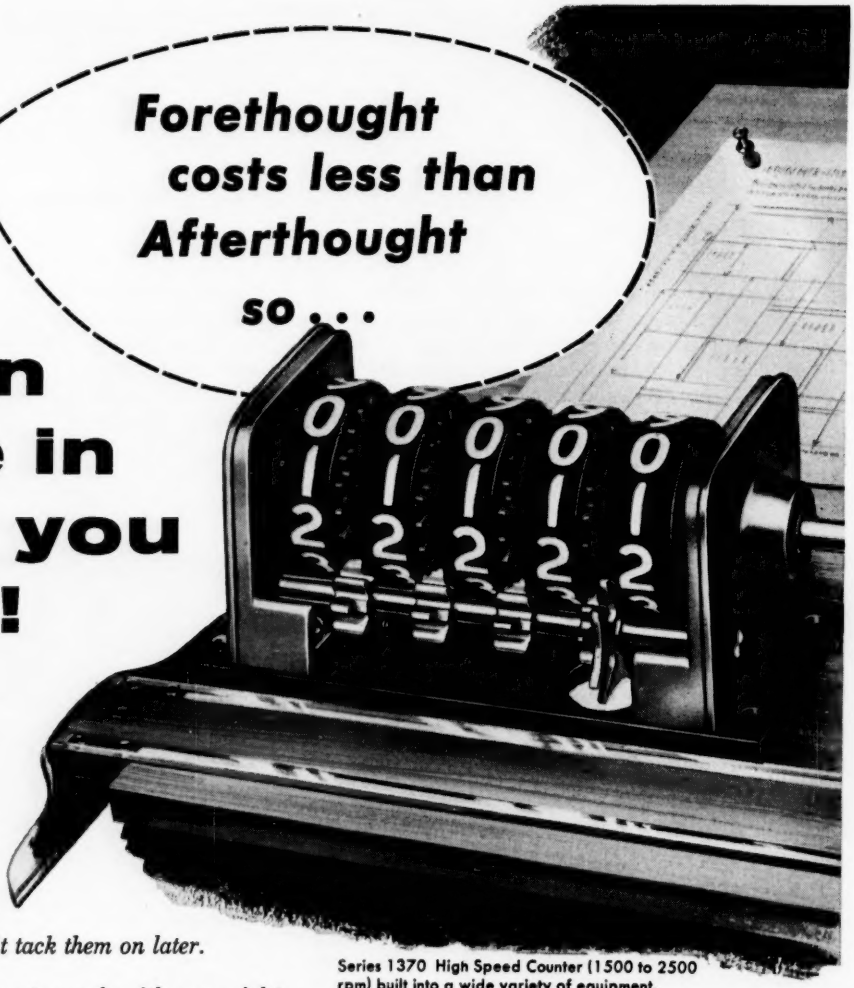
MOOG VALVE CO., INC. PRONER AIRPORT, EAST AURORA, NEW YORK

Research Laboratory, Paramus, New Jersey

For more information circle **52** on inquiry card.

Forethought costs less than Afterthought so . . .

Design These in When you Begin!



Series 1370 High Speed Counter (1500 to 2500 rpm) built into a wide variety of equipment.

If you need mechanical or electrical counters in any of your new products, here's a word to the cost-wise designer: *Design them in, when you begin . . . don't tack them on later.*

For if you'll give us a chance to work with you, right from the beginning, chances are we can save you time and money by adapting or modifying a *standard* Veeder-Root Counter to your needs . . where you might get into a costly special job if you went about it alone. What's more, you save time in your engineering, purchasing and assembly departments.

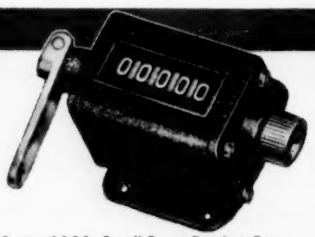
Count on Veeder-Root to help you in every way . . . from design to delivery. Write:

Everyone... Can Count on Veeder-Root

INCORPORATED

Hartford, Conn. • Greenville, S. C. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

Series 1205 Reset Magnetic Counter with panel mount and lock and key.



Series 1122 Small Reset Ratchet Counter.

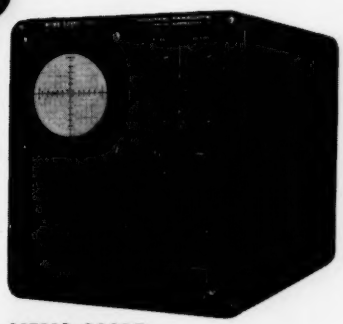
Special Longitude Counter, one of many made for aircraft navigational equipment.

For more information circle **53** on inquiry card.

Three unusual direct-display storage tubes by Hughes

MEMOTRON

FEATURES: bright display . . . constant and uniform intensity of presentation . . . no perceptible transient decay . . . simplifies photography. APPLICATIONS: transient analysis . . . spectrum analysis . . . direct comparison of wave forms. SPECIFICATIONS: 100,000 inches/sec. writing speed . . . stores traces until intentionally erased . . . erasure triggered by push-button, or programmed voltage . . . electrostatic focusing and deflection.



MEMO-SCOPE

Model 104, incorporating MEMOTRON, is a new memory oscilloscope with 5 optional preamplifiers to satisfy the most critical production, test and laboratory requirements.

TONOTRON

FEATURES: half-tone presentation . . . excellent grey scale . . . controllable decay rate . . . compact design. APPLICATIONS: closed circuit TV . . . instrumentation . . . P.P.I. . . . narrow band, slow scan TV. SPECIFICATIONS: 1,000 foot-lamberts brightness at 10 kv . . . electrostatic focusing . . . magnetic deflection . . . . 60 lines per inch resolution . . . writing speed of 150,000 inches/sec.

TYPOTRON

FEATURES: high brightness . . . permanent display until intentionally erased . . . rapid display of printed data . . . 63 character matrix. APPLICATIONS: digital computers . . . teletype reception . . . wherever printed data must be displayed rapidly for use by human operator. SPECIFICATIONS: writes up to 25,000 characters/sec. . . . permanent storage until erased . . . almost instantaneous erasure . . . electrostatic focusing and deflection.

See demonstrations of these tubes and MEMO-SCOPE *at the I.R.E. Show, booths 2801, 2803, 2805, Second Floor. For additional information write to:*

HUGHES PRODUCTS • ELECTRON TUBES
International Airport Station, Los Angeles 45, California

HUGHES PRODUCTS

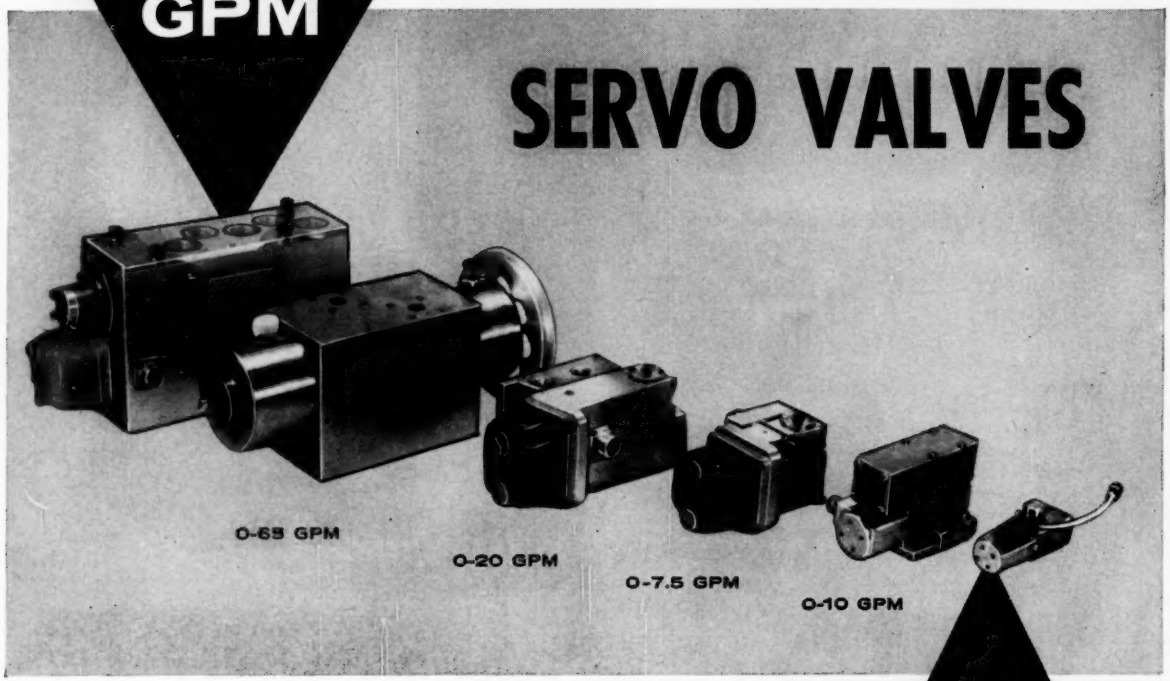
© 1957, HUGHES AIRCRAFT COMPANY

For more information circle **54** on inquiry card.

0-175 GPM

SANDERS Electro-hydraulic

SERVO VALVES



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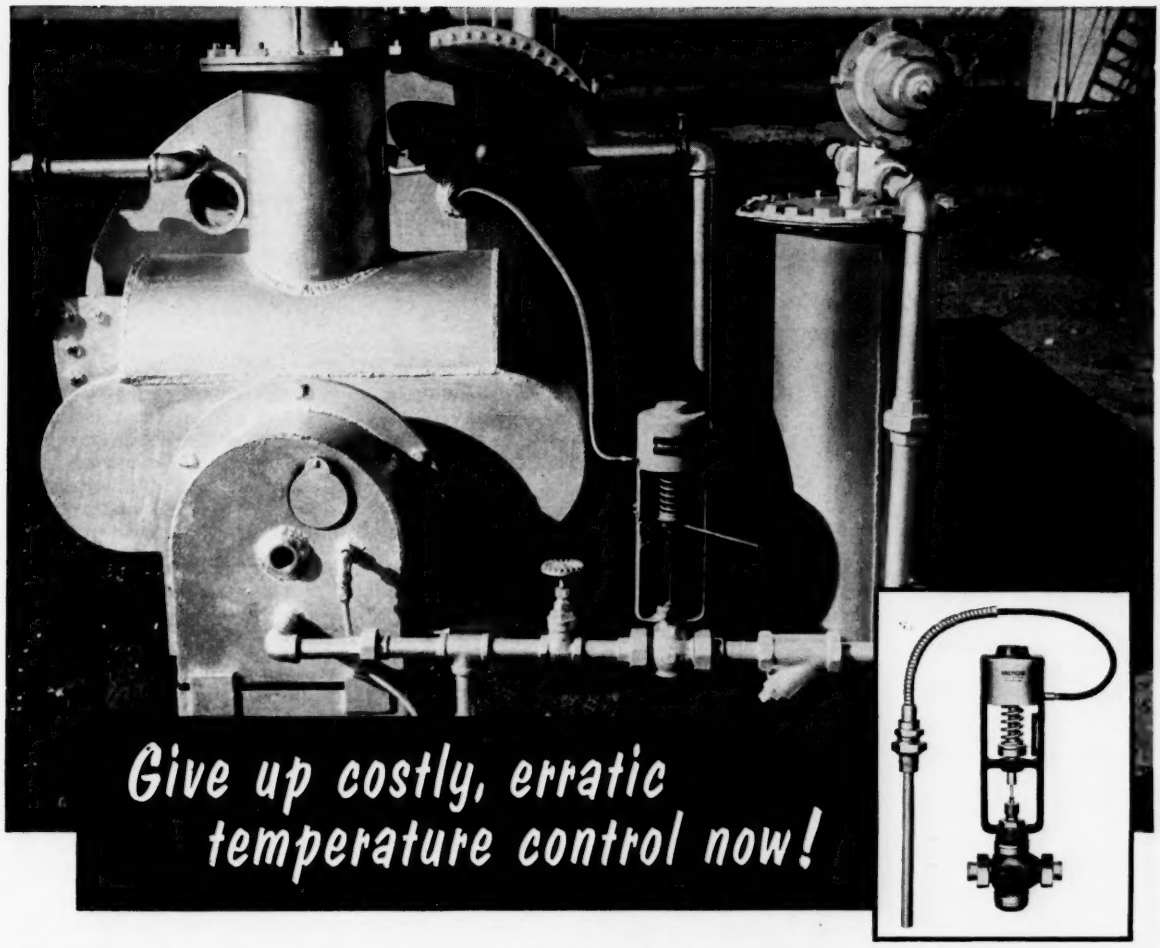

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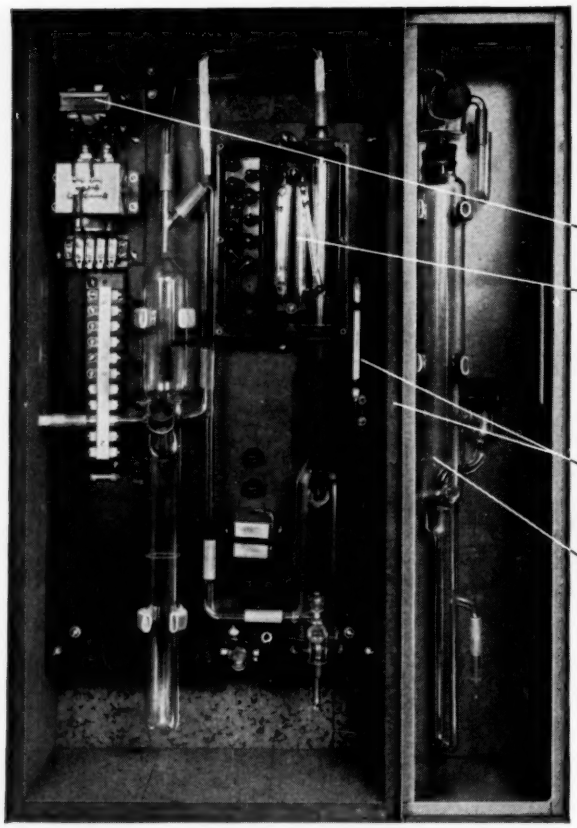

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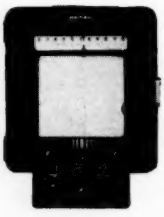

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INSTRUMENTS and AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—*M. H. Aronson*, Editor

Editorial

Systems Engineering and the Instrument Manufacturer

Permit us to raise a skeptical eyebrow at the way instrument manufacturers are becoming enamoured of the systems engineering concept—as it affects their particular business. Like the married man attracted to a female *objet d'art*, the instrument manufacturer should not lose sight of his responsibilities at home.

Instrument manufacturers always have been ready to assist the user to apply instruments properly. This type of consultation and assistance, which has not been inexpensive, is in itself a form of systems engineering, and has been one of the major costs to the manufacturer. But complete systems engineering—analytical, experimental, quantitative consultation on all or parts of the user's system—is far more costly and quite different in purpose, scope, and conclusion. For example, a systems analysis often includes decisions at the management level about hardware to be supplied by many manufacturers. It is basically a consultation and analysis function with definite moral problems for the hardware manufacturer who attempts systems engineering—and for the systems engineering company that develops a line of standardized hardware.

Referring again to the primary responsibility of the instrument manufacturer, there is evidence that the breadwinning lines of hardware suffer when the manufacturer turns to systems engineering. The problems of systems engineering are exceedingly difficult and involved, and time and attention are necessarily diverted away from the problems of promoting a line of superior hardware to the problems of analyzing individual systems. It is obvious that the same amount of attention and effort directed to the problem of producing, applying and selling the product lines would have had some effect. The result is that the main lines, the company breadwinners, do not receive the attention they deserve.

Still another important and little-considered factor is the attitude of the instrument engineer of the plant or plant constructor to outside "systems engineering." Today the instrument engineer is the biggest customer of the instrument manufacturer, and he is not always happy to hear that an outside agency is "systems engineering" his plant. He is even less happy at the conclusion of a project to discover that the instrument supplier now claims to have "system engineered" the entire project for which he was the instrument engineer.

Consultation and instrument manufacturing are essentially and basically different occupations, although much cooperation is required between the instrument manufacturer and the consulting engineer. But today the instrument engineers working for the plant or the plant constructor are actually the single largest body of systems engineers, whether they are called systems engineers or not. This group of men are, in general, aware of their systems problems, and either know or are learning systems engineering techniques. The instrument manufacturer will do well to examine all the implications of systems engineering before he places the concept above his hardware sales in importance, and begins to compete for systems engineering business. In industry, in particular, he may find himself at odds with his best customers.

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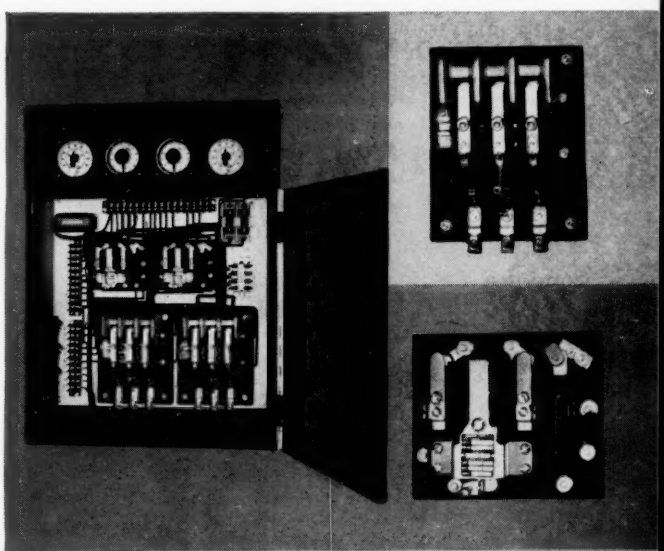
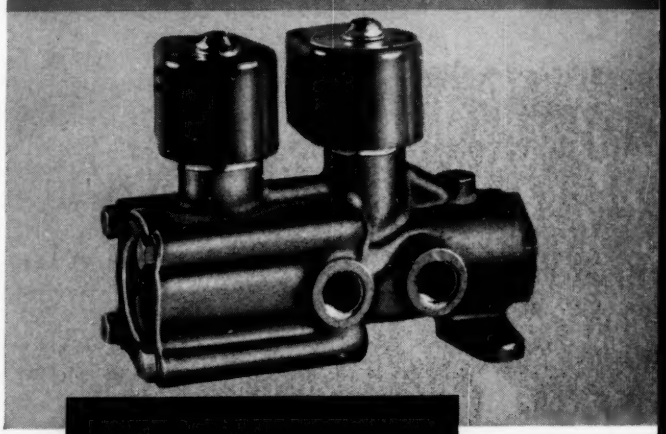
Dependable precision control by ASCO has been a long time feature of a wide range of automatic equipment and machine tools. A typical example is the Shell-O-Matic high speed shell molding machine shown here. The machine produces precision shell molds for casting in ferrous and non-ferrous metals. ASCO solenoid valves sequenced by ASCO relays completely control the operation.

Integrated in the control system are the ASCO control panel, single and dual solenoid valves with watertight molded coils, relays and contactors. These controls help Shell-O-Matic achieve a production rate of 50 precision units per hour.



ASCO CONTROL PANEL

This control panel consists basically of two ASCO 1054 Relays and 1035 Contactors. The 1054 is especially designed for rugged industrial use with powerful efficient magnet for positive action. It is a 25 ampere relay, available in a variety of pole combinations up to 12 poles. The Bulletin 1035 is a continuous duty contactor, suitable for all classes of load, with interrupting capacity of 6 times rated current. Standard ratings are to 300 amperes; contactors with higher capacities are available.



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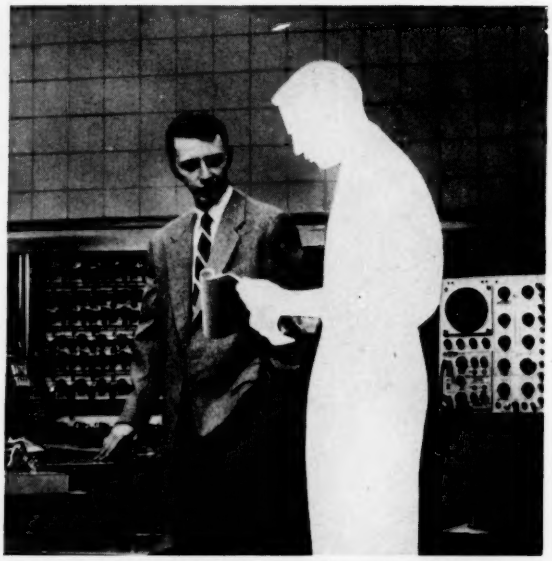
IBM GROWTH promoted these men

PRODUCT DEVELOPMENT ENGINEER: Before his recent promotion, this man was a member of a small engineering "team" (two M.E.'s, an E.E. and a model maker) in IBM's Poughkeepsie plant. His specific project entailed the creation of the "ultimate package in printed circuitry." His group "brainstormed" the project in continual sessions, putting the results in model form. Then the group would try to "tear the idea to shreds" in order to create something even better.



PRODUCT CONTROL ENGINEER: Promoted recently, this man formerly worked at IBM's Poughkeepsie manufacturing facilities. His job was to design information systems to insure a smooth flow of work through the plant. "It takes *creative* engineering ability to design these systems," he'll tell you, "and *administrative* ability to 'sell' a system to higher management and make it stick. If you possess this rare combination of abilities, this is the job for you!"

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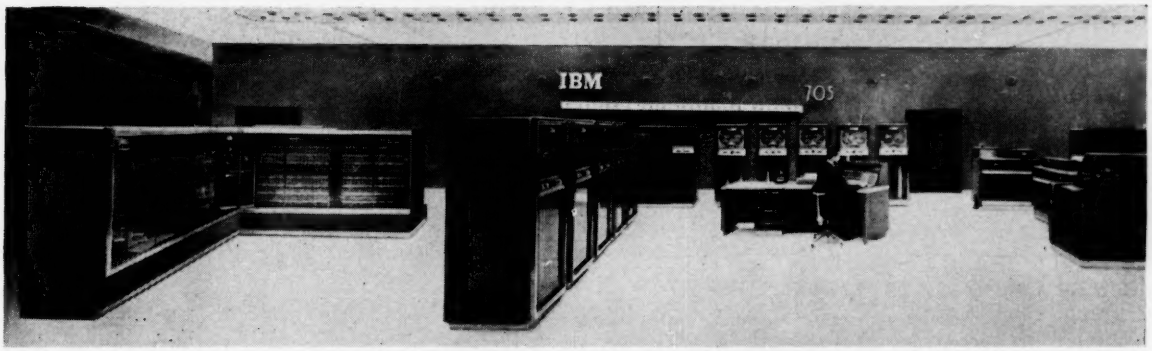


Fig 17-1. IBM type 705 is in the class of large, powerful digital computers or electronic data processing machines (EDPM's). Tape units in background can introduce data into the machine at a rate of more than 12,000 bits per sec. Tape reaches full speed (start/stop time) in 10 ms.

DIGITAL COMPUTERS

DIGITAL AUTOMATION—NO. 17

The basic digital computer operations are addition, subtraction and multiplication. Here is a clear and thorough introduction to digital computer techniques, including rapid parallel multiplication based on right-shift, left-shift, and "AND" check for oddness.

MARTIN L. KLEIN
FRANK K. WILLIAMS
HARRY C. MORGAN
Rocketdyne Div.,
North American Aviation, Inc.

DURING the past fifteen years there has been a tremendous upsurge of activity in the field of automatic computation. During this period the field has broken into two distinct parts, one known as *analog* and the other as *digital* computation. It can be said that the analog computer operates continuously on input information whereas the digital computer operates on discrete quantities representing numbers. We are concerned with the latter only.

There are in existence today more than twenty-five commercial digital computers; these range in price from some thirty-thousand dollars up to seven or eight million dollars (Table 17-1). Fig. 17-1 shows a typical commercial computer installation of the million-dollar class; smaller commercial units are shown in Fig. 17-2.

Design Vs Programming

Generally speaking, there are two types of effort being carried out simultaneously, and one finds that persons who are proficient in one are not usually proficient in the other. These two classes are *programming* and *designing*.

The former field is largely mathematical and has to do with the techniques of physically operating the machine and adapting an existing machine to do mathematical analyses of various problems. The latter field is concerned primarily with the engineering and internal operations of the machine. Both of these fields are progressing at such an incredible rate that it is virtually impossible to keep up-to-date on both. However, we shall discuss both the techniques used internally in the design of the machine and some of the programming; the reader can decide in which direction his interest lies.

Computer Elements

All digital computers have the four basic parts shown in Fig. 17-3. The *input* refers to equipments and methods for presenting data and instructions to the machine. The *memory* refers to that part of the system which stores the data, instructions, and results of computation. The computations are carried out in a part of the system known as the *operational circuitry*, which is capable of performing a series of simple logical operations (ordinarily arithmetic) at high speed. Finally, the system has an *output*, which refers to the methods and equipments which convey the results of a computation back to the operator.

A simple example of these elements can be seen by referring to a desk calculator such as a Comptometer. The keyboard can be thought of as the input. The memory

Table 17-1—Characteristics of Electronic Computers

COMPUTER	Mfgr.	Price	Number System	Word Size	Internal Storage	Input	Output
Alwac III-E	Alwac Corp.	$48,000	Binary	32 bits	Mag. drum Mag. tape	Flexowriter Punched card Paper tape Mag. tape	Flexowriter Punched card Paper tape Mag. tape
Alwac 800 system	do	$200,000	Decimal	12 digits	Mag. core Mag. drum Mag. tape	Mag. tape Punched card Paper tape Keyboard Flexowriter	Speed printer Punched cards Paper tape Mag. tape Flexowriter
G-15A	Bendix Aviation	$44,800 $1350/mo. rent	Binary	29 bits	Mag. drum	Typewriter Paper tape Magnetic tape	Typewriter Paper tape Magnetic tape
G-15D	do	$49,500 $1485/mo. rent	Binary	29 bits	Mag. drum	Typewriter Paper tape Magnetic tape Punched card conv.	Typewriter Paper tape Magnetic tape Paper tape punch Punched card conv.
DA-1(DDA)	do	$13,700 $555/mo. rent (+G-15D	Binary	28 bits	Mag. Drum	Graph plotter/ follower G-15D input equipment	Graph plotter G-15D output equipment
E-101	Electrodata Div. of Burroughs Corp.	$38,000 $1000/mo. rent	Decimal	12 digits	Mag. drum	Punch tape Accounting Machines	Punched tape Accounting machines
Datatron	do	$135,000 $3900/mo. rent	Decimal	10 digits	Mag. drum	Keyboard Punched Cards Paper tape Magnetic tape	Flexowriter Punched cards Line printer Magnetic tape
LGP-30	Royal McBee Corp.	$39,600 $1100/mo.	Binary	32 bits	Mag. drum	Flexowriter	Flexowriter
IBM 650	International Business Machines	$3750/mo. rent-to $20,000	Decimal	10 digits	Mag. drum Mag. cores Disk storage	IBM cards Mag. tape	IBM cards Printer Mag. tape
IBM 701	do	$17,000/ mo. rent	Binary	36 bits or 18 bits	Mag. drum Electrostatic Mag. core	IBM cards Mag. tape	IBM cards Printer Mag. tape 740-CRT 780-Display
IBM 702	do	$25,000/ mo. rent	Decimal	Variable	Mag. drum Electrostatic Mag. core	IBM cards Mag. tape	IBM cards Printer Mag. tape
IBM 704	do	$35,000/ mo. rent	Binary	36 bits	Mag. core Mag. drum	IBM cards Mag. tape	IBM cards Printer Mag. tape 740-CRT 780-Display
IBM 705	do	$30,000/ mo.	Decimal	Same as 702	Mag. core Mag. drum	IBM cards Mag. tape	IBM cards Printer Mag. tape
Univac I	Remington Rand	$25,000/mo.	Binary-coded decimal	12 digits	Acoustic delay line	Cards, Paper tape, Mag. tape	Mag. tape to cards, Paper tape, Printer Typewriter
Univac II	do	$30,000/mo.	Binary-coded decimal	12 digits	Mag. cores	Cards, Paper tape, Typewriter to mag. tape	Mag. tape to cards, Paper tape, Speed printer, Typewriter
Univac Scientific 1103A	do	$32,500/mo.	Binary	36 bits	Mag. cores Mag. drums	Mag. tape Cards Paper tape	Cards Paper tape Mag. tape
Monrobot	Monroe Calc. Mach. Co.	$75,000	Decimal	20 digits	Mag. Drum	Flexowriter	Flexowriter
Readix	J. B. Rea Co.	$98,000	Decimal	10 digits	Mag. drum	Flexowriter Punched tape Mag. tape IBM cards	Flexowriter Punched tape Mag. tape IBM cards Point plotter
Elecom 50	Underwood Corporation	$25,000	Decimal	10 digits	Mag. drum	Accounting machines	Accounting machines
Elecom 125 System	do	$350,000	Decimal	10 digits	Mag. drum Acoustic delay lines	Mag. tape Punched tape Flexowriter Punched cards	Mag. tape Punched tape Flexowriter Punched cards

Fig. 17-2. Typical general-purpose digital computers in the economy class.

is a set of gears whose positions represent the data. The computations are carried out by the gear mechanism in a sequence which must be remembered by the machine operator (here the operational circuitry is half mechanical and half human). Finally, the output is obtained from a series of engraved wheels representing numbers.

When the operator executes the operations in the correct sequence—that is, adds two numbers, then divides, then multiplies, and so on—he is executing a *program*. Ordinarily, the digital computers which we shall discuss are capable of storing the program so that the operator is relieved of all operational details; once the machine has been instructed as to the correct sequence of events, it will perform that sequence of events without any further human help.

The principal advantage of a digital computer over a Comptometer is that the former is capable of remembering what steps to take to complete an entire program, and can execute these steps at speeds up to several hundred thousand per second.

Input Equipment

Several types of input equipment can be used, depending on the particular computer and the particular application. It is essential that both the designer and programmer know exactly which kind of input equipment can be used with each machine, and how it is used. Some input equipments, in order of the speed with which they introduce data into the machine, are:

1. Keyboard
2. Electric typewriter
3. Hollerith card
4. Perforated tape
5. Magnetic tape

The first two are fairly well known, as is the third, the Hollerith card (Fig. 17-4). Perforated tape is simply a role of paper in which holes are mechanically punched according to a fixed code; the holes ordinarily are sensed by a photoelectric cell and light arrangement.

Magnetic tape is the fastest of the five methods listed. There are several methods for recording on tape, but all essentially use bits in which a "zero" might be negative tape saturation and a "one" might be positive tape saturation. The most efficient method is known as *no-return-to-zero* (NRZ) in which a *change* from positive to negative saturation, or vice versa, represents a "one" and no change represents a "zero," as shown in Fig. 17-5.

In addition to having different types of input equipment, different machines use different codes. The code can vary even between the machines of one manufacturer. For example, the IBM 650 uses binary-coded decimal

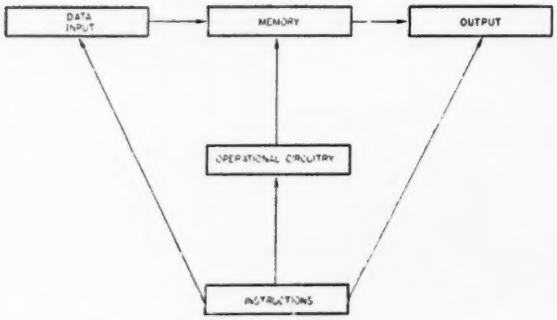


Fig. 17-3. Elements of a digital computer.

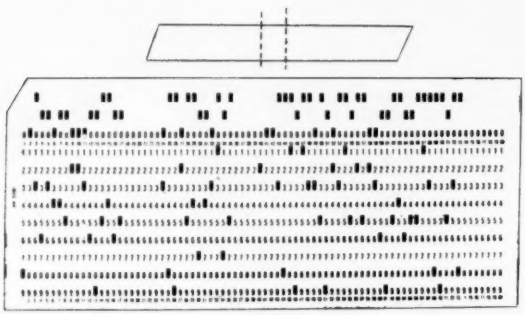


Fig. 17-4. The Hollerith punched card is a basic input medium for digital computers. Card shown contains 80 vertical columns. Black areas represent holes in card. All the data on the card can be placed on magnetic tape on the area shown between the dotted lines.

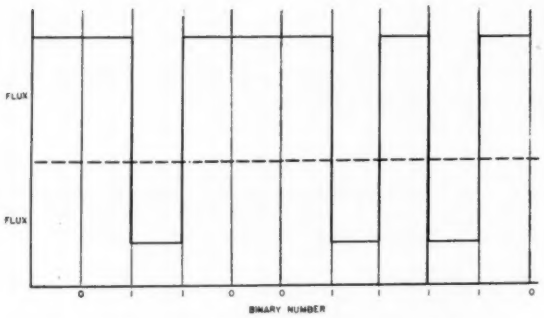


Fig. 17-5. In NRZ magnetic tape recording, a change from positive to negative (or negative to positive) magnetic saturation represents a "1." No change in saturation represents a "0." Tape saturation is shown for binary number 0110011110.

tape; the IBM 704 binary cards. It might also be added that each machine usually has several possible inputs. Thus the IBM 650 accepts information from either a Hollerith card, a magnetic tape, or a keyboard arrangement on the computer console.

One must be completely familiar with the nature of the codes used because it usually is not a simple task to change from one type of code (such as binary) into another (such as binary-coded decimal).

Input Figure of Merit

A good test of the efficiency of a computer is the time it takes to accept data divided by the operating cost per hour. This is known as the *input figure of merit.* For example, the IBM 704 accepts 1.5×10^8 bits per hour at a cost of $300 per hour, representing an input figure of merit of ½ million input bits per dollar. This is a good gage for the efficiency of any machine because most of the machine time usually is used in taking in and putting out data, and the computational time is not very great by comparison. This is especially true where a machine is used for data processing or in business applications.

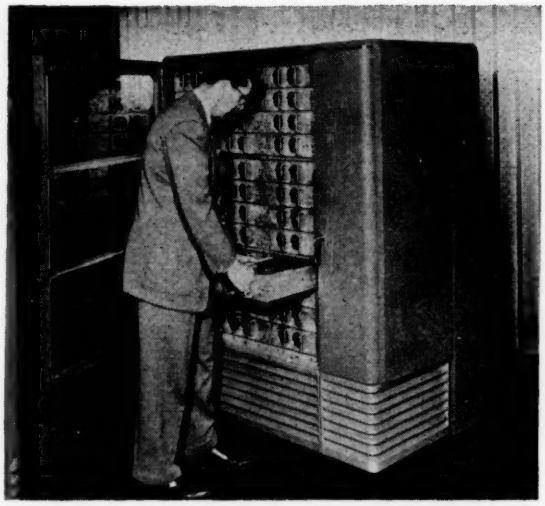


Fig. 17-6. Banks of cathode-ray tubes in the IBM Electronic Data Processing Machines comprise the electrostatic storage units. Data can be placed in electrostatic storage or obtained from it in 12 microseconds.

Memory

Machine memory technique is limited to five standard practices. In order of speed of operation and availability of the information stored they are:

1. Gears and mechanical contrivances.
2. Relays
3. Magnetic drums
4. Storage tubes
5. Cores

The first two are largely obsolete—except that gears are common in desk calculators (which are not digital computers in our meaning of the word). *Relays* are, at best, unreliable and space consuming in the large numbers necessary in a memory.

Storage tubes (Fig. 17-6) are in common use but suffer from aging properties and "sleeping sickness" (a property whereby, if the tube has to remember a bit for too long a period of time, it is reluctant to give it up when questioned). The present trend is to *core memories* (Fig. 17-7) because of their economy and very high operating speeds. However, *magnetic drums* are still in general use (Fig. 17-8).

A core memory can be any size, limited only by the cost. Thus, for example, a core is being designed which will retain more than 35,000 36-bit words, and any word can be reached in less than 2 microseconds. (For interest, it has been estimated that the human memory is capable of storing twenty billion bits, but it is not nearly as fast as even a relay memory.) There is also under development a memory device which uses no electric power at all; it is based on the superconductivity of

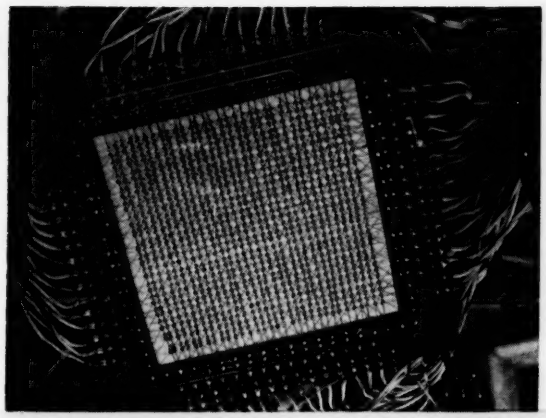


Fig 17-7. UNIVAC core memory unit consists of a 32 x 32 matrix of tiny cores.

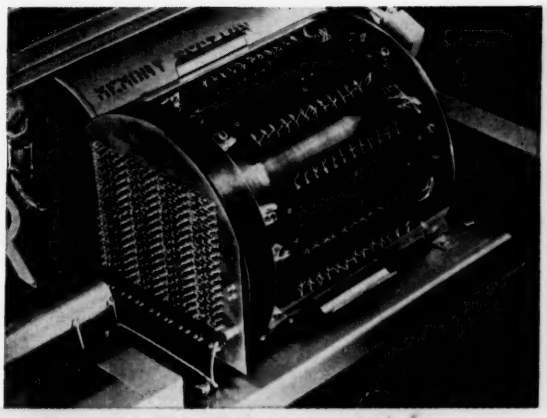


Fig. 17-8. The LGP-30 magnetic-drum memory has 64 heads, each of which can record 64 words of information on its track, giving a bulk memory of 4096 words. Each word is a 32-bit number. As drum rotates at 3600 rpm, any word is accessible in 17 ms —but special interlace feature for minimum-access-time coding reduces usual access time to 2 ms.

metals whereby a current induced in a piece of metal at 4° Kelvin will circulate perpetually. The practical realization is some years away, but this will make possible a machine memory of human capacity.

Memory devices should have short *access time* so that the computer can obtain its information rapidly, thus making possible a fast series of operations inside the machine. The longer it takes the machine to look up a number (numbers are usually called *words* in computer language) the longer it takes the machine to make its computation. Most machines perform their operations on information which they obtain from this internal memory, and then the machine places the results of computation at some other location in the memory. Where to get the correct information at the correct time, and where to put it when the computation has been made, is part of the operation called *programming*. The machine user, in writing his program, must keep track of where each operation is going to come from and where each result is to be placed.

Operational Circuitry

Once the information is obtained from the memory, some computation has to be made. The simplest computations are the four arithmetic operations—add, subtract, multiply, and divide. By putting in a code number, the user programs the machine for the specific operation he desires, and the machine executes the necessary electronic steps to perform this operation. These steps have been designed into the machine by the designer so that when the machine recognizes a certain code number representing, say, ADD, it goes through all of the necessary steps to add the two numbers that it has been instructed to add. Then it goes on to the next step. Designers have become ingenuous at performing these arithmetic operations electronically; we shall discuss some circuitry in a following discussion.

In addition to the basic instructions, the machine can have up to sixty or seventy more instructions which are used at one time or another. These include such common ones as *left-shift* (which essentially doubles a number), *right-shift* (which halves it), *complement, square-root, compare, transfer on zero*, etc. We will discuss these also a bit later.

Output

The equipments used for machine outputs are generally the same as for the inputs. In fact, the same devices are used at one time to put data into the computer and at another time to display data coming out of the computer. Most computers will automatically change the input device to an output device when it is ready to display the computation.

Having summarized the basic elements of a programmed digital computer, we will now show, using only the circuitry described in earlier chapters, how arithmetic can be performed electronically, and then we will demonstrate the programming for a digital computer that is representative of most computers.

Serial Addition

Probably the simplest mode of addition, electronically, is by serial counting of input pulses. This can be done (Fig. 17-9) by using two registers, a clock which emits pulses, and a gate. The two numbers to be added are entered into the registers, as shown. Note that one of the counts is complemented before being added into the register.

When the gate is opened, the clock pulses feed simultaneous into both registers. When the register containing the complement is filled, the next count overflows and closes the gate. The count now standing in "A" register is the sum of the two original counts.

This technique for serial addition, although simple in design, is time consuming. Thus, if the clock is operated at one megacycle per second, a 10-bit number (which represents only 4 decimal digits) requires up to one millisecond for a single addition (because the 10-flip-flop counter starting from zero must count 1024 1-Mc pulses in order to return to zero; this requires 1024 usec, or about 1 millisecond). For this reason this technique is not in general use.

Parallel Addition

Parallel addition is faster than serial addition. A typical circuit for parallel addition of two single-bit numbers

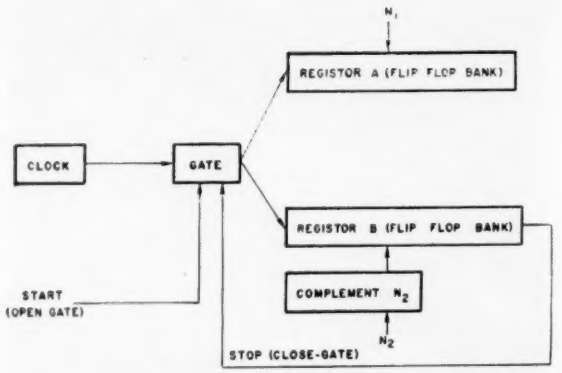


Fig. 17-9. Serial addition uses clock pulses and a gate controlled by the complement of one of the numbers to be added.

is shown in Fig. 17-10. Note that a considerable amount of diode logic is incorporated into each stage because there are essentially three inputs—two of the inputs represent the bits to be added; the third input represents the carry from the next least-significant stage. Let us call one input A, the second input B, and third input (the carry) C.

Let us also say that $\overline{A}$, $\overline{B}$, or $\overline{C}$ represents a zero (no signal), or "not" signal. That is, $\overline{A}$ means "not A."

There are four possible conditions whereby the sum of the 3 inputs will be a "1":

$$A+\overline{B}+\overline{C}=1+0+0=1$$
$$\overline{A}+B+\overline{C}=0+1+0=1$$
$$\overline{A}+\overline{B}+C=0+0+1=1$$
$$A+B+C=1+1+1=1$$

Thus we can state that all the possible conditions for a sum of 1 to be generated are:

$$\text{Sum} = 1 = A\overline{B}\overline{C} + \overline{A}B\overline{C} + \overline{A}\overline{B}C + ABC \quad (1)$$

in which the + sign is read "or."

A carry signal will be generated whenever any two of the inputs are 1. Thus, the following logic expresses the simultaneous presentation of these inputs:

$$\text{Sum} = A\overline{B}\overline{C} + \overline{A}B\overline{C} + \overline{A}\overline{B}C + ABC = 1 \quad (1)$$
$$\text{Carry} = AB + BC + AC = 1 \quad (2)$$

For example, let us add A = 1, B = 1, and C = 0. This means that we are adding two ones and that there is no carry from the previous stage. By referring to equation one, we can say that we have in effect $AB\overline{C}$ and, since this is not part of equation 1, the sum is 0. The simultaneous presentation of A and B shows (equation 2) that a carry will be generated.

Fig. 17-10 shows the circuitry for the logic in equations 1 and 2; all of the bits and carries can be met simultaneously at high speed (0.1 microsecond in the circuit shown). Here, then, is a technique for high-speed addition.

It is possible to operate in a combined serial-parallel mode in which a number of, say, 36 bits is considered as two 18-bit numbers; the additions are made serially on both halves of the number simultaneously, and then the carry is added. However, even though this is used in existing machines, there is no real advantage because extremely high speeds are now possible with the parallel adder.

Serial Subtraction

A slight modification of the serial adder converts it into a *subtract* circuit. Thus, if one hooks some flip-flops as shown in Fig. 17-11 it is possible to make this register count up or down. For example, if the *Add* gates are enabled, the flip-flops will count in a conventional manner. But, if the *Subtract* gates are enabled, the counter will count backwards. If we have a 3-bit register and we make it count backwards by enabling the subtract gates, the count will proceed in this way:

101—5, etc.
110—6
111—7

The counters are now counting in reverse.

If we wish to subtract one number from the next, we store the larger number in the "A" register in Fig. 17-9, and the number to be subtracted is entered in complement into register B. Let register A in Fig. 17-9 be a reversible counter like that shown in Fig. 17-11. A d-c negative enabling voltage is supplied to the count backward gate while the count forward gate is disabled by a positive voltage. The gate is opened and the circuit will now subtract as the clock pulses enter, until the complement register B overflows and closes the gate.

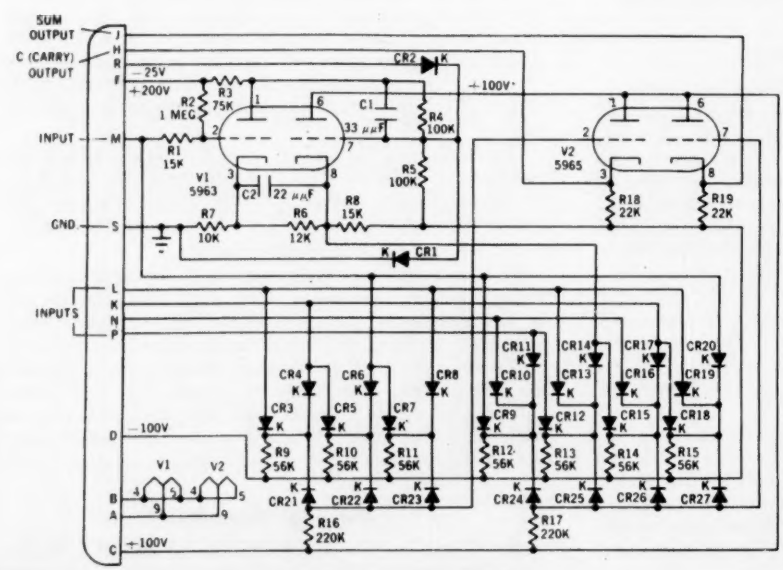


Fig. 17-10. Circuit for parallel addition of two 1-bit numbers. Note that there are 3 inputs—the two bits to be added and the carry bit from a preceding stage.

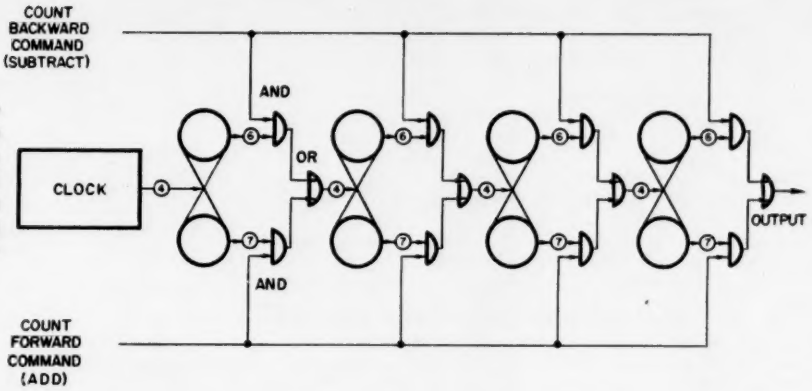


Fig. 17-11. Reversible counter can be made to count up or down by use of two "and" circuits and one "or" circuits between flip-flop stages, resulting in a serial adder or subtracter.

The count standing in the A register is now the difference between the two. We now have a circuit which will either subtract or add according to which command is given.

The serial subtracter suffers from the same disadvantages as the serial adder—that is, a considerable amount of time is necessary to make a subtraction. Thus, a 10-bit number could require as long as one millisecond if 0 is subtracted and the clock operates at one megacycle. Accordingly, a *parallel subtracter* has been devised which will perform the operation at high speeds.

Parallel Subtraction

The parallel subtracter (Fig. 17-12) again requires three inputs, one of which is a *borrow* from the least-most significant bit. Thus, if one input is X (the minuend), the other input is Y (the subtrahend), and the borrow is B (from the next most-significant bit), it can be shown that the following logic equations express all possible relations between X, Y, and B in order to perform subtraction of Y from X.

$$\text{Difference} = X\overline{Y}\overline{B} + \overline{X}\overline{Y}B + \overline{X}Y\overline{B} + XYB \qquad (3)$$

$$\text{Borrow} = \overline{X}Y\overline{B} + \overline{X}\overline{Y}B + \overline{X}YB + XYB \qquad (4)$$

Equation 4 reduced becomes:

$$\text{Borrow} = \overline{X}Y\overline{B} + \overline{X}YB + YB$$

Fig. 17-12 shows a commercial plug-in one-digit subtraction matrix which will subtract either in series or parallel. Several units can be combined to obtain subtraction to the desired binary power. The logic of equations 3 and 4 is incorporated in the diode arrangements of Fig. 17-12 and high operational rates are possible. Of course there are other possible ways of adding and subtracting (two of the fundamental operations of any digital computer).

Electronic Multiplication

Multiplication, as was shown in Chapter 2, is essentially a series of shifts and additions in binary code. In principle then, one can multiply simply by adding. However, a neat way of multiplying consists of the *halving and doubling technique.*

If we wish to multiply the decimal numbers 7 and 3, let us continue to halve either number (7), throwing away any remainder and simultaneously doubling the other number (3). In chart form, this would look like this:

7	3	(Left column is odd)
3	6	(Left column is odd)
1	12	(Left column is odd)
0	24	(Left column is even)

Examining the left-hand column, wherever the number is odd, retain the number in the right-hand column. (Consider 0 to be even.) If we follow this convention and sum the number retained, we find that we have the sum of 3, 6, and 12, which is 21 the desired product.

If we apply this technique to the product of 8 and 3 we get

8	3	
4	6	
2	12	
1	24	(Left column odd)
0	48	

and the result is 24.

What makes this particularly attractive in a binary computer is that one can halve a number and throw

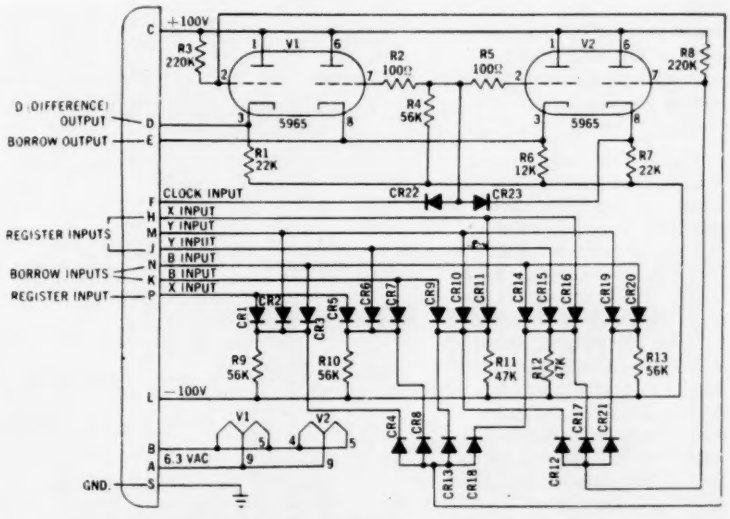


Fig. 17-12 Subtracter circuit that will subtract a 1-bit number from another 1-bit number, either by parallel or serial subtraction.

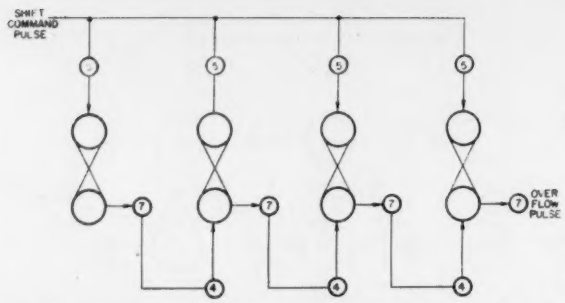


Fig. 17-13. Right-shift register comprises a series of flip-flops. When a "shift" command pulse is received, only a flip-flop in the 1-state and/or to the right of a flip-flop in the 1 state will change state.

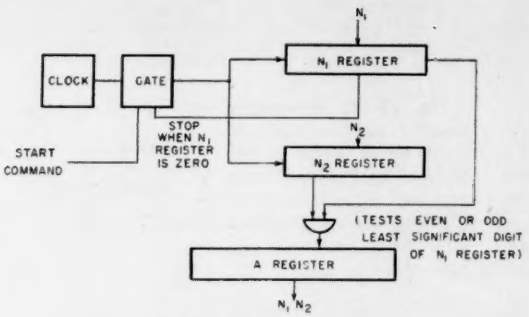


Fig. 17-14. Block diagram of system for parallel multiplication.

away the remainder by the simple trick of *right-shifting* it, thus:

$$111 = 7$$
$$11 = 3$$
$$1 = 1$$
$$0 = 0$$

Similarly, one can double a number by *left-shifting* it. Thus:

$$011 = 3$$
$$0110 = 6$$
$$1100 = 12$$

It is also evident that a binary number always can be tested for oddness by looking at the least-significant bit—if the number is odd, that bit will always be occupied by a one. Thus we see that simply by use of left shift, right shift, and testing the least-significant bit, we can rapidly multiply numbers in binary code.

Multiplication Circuitry

In order to multiply two binary numbers, we must store them in registers, right-shift one register, left-shift the other, and test the least-significant bit. Fig. 17-13 shows a circuit for a right-shift register. The count (or number in the register) is indicated by the state of the flip-flops. Upon receipt of a "shift" command pulse, a pulse is carried to the next stage if and only if a count was stored in the previous stage.

Fig. 17-14 shows a system for *parallel multiplication*. It has three registers, two of which contain the numbers to be multiplied and one to store the sums. The registers are shift registers. If we wish to multiply 7x3, as previously suggested, the 7 is stored in the N1 register, which right shifts to halve the numbers; the 3 is stored in the N2 register, which left shifts to double the numbers. The "A" register is to contain the product.

After the numbers are introduced, we test the least-significant bit (by using the "and" gate). This transfers the count standing in the lower register into the "A" register if the count in the N1 register is odd. We then right-shift the top register, left-shift the bottom register, test the last bit, and add the new count to the count already stored in the register (if the N1 register count is still odd). This is repeated to completion, which is indicated when a 0 count stands in the N1 register. The complete circuitry for performing these operations is shown in Fig. 17-15.

The time to make a multiplication is thus:

(No. of Bits) (Time to shift + Time to sum)

If it takes one microsecond per operation, a multiplication of a 10-bit number would take twenty microseconds.

Note also that the product occupies more register space than either of the two numbers being multiplied, and the "A" register must be made large enough to accommodate the largest number of bits that can be generated. Thus, a 20-bit "A" register is needed for multiplying two 10-bit numbers. For addition of two 10-bit numbers, however, the "A" register need only be eleven bits long. Ordinarily, if the result exceeds the size of the register, an overflow light is energized, and the computer is automatically stopped.

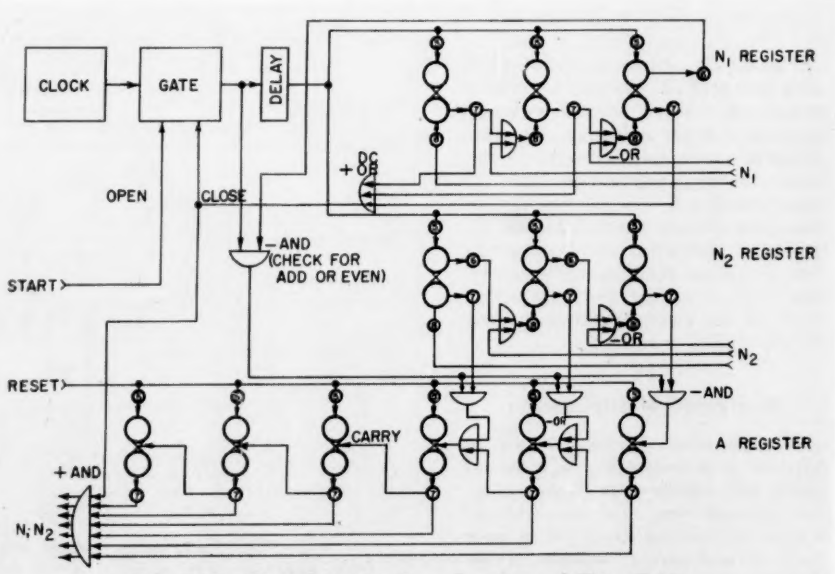
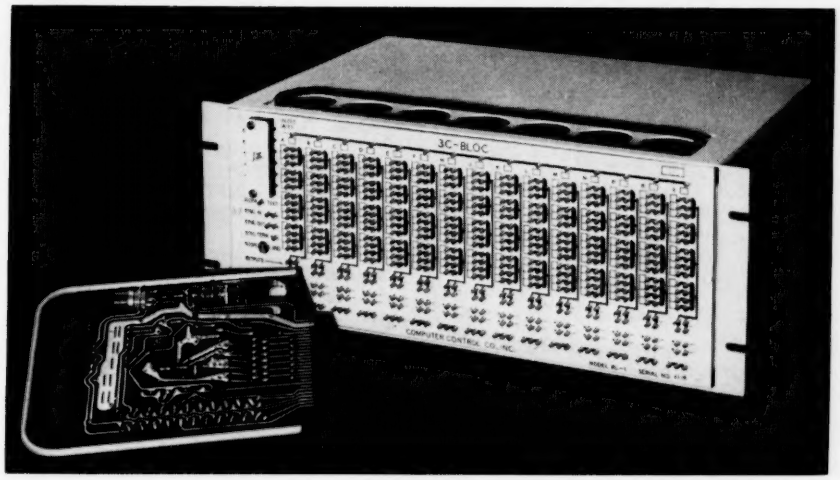


Fig. 17-15. Complete circuitry of system of Fig. 17-14.



The physical embodiment of symbolic logic principles.

Logical Design *with* Symbolic Logic

ROBERT W. BROOKS
Computer Control Company, Inc.

The combination of binary numbers and a few simple logical operations is a powerful means for computation and control. Here is a clear and thorough introduction to symbolic logic, whose end uses in logical design are limitless.

It is a remarkable and useful fact that complex logical manipulations and numerical computations can be built up from a few simple operations involving symbolic logic.

Logic involves the conditional relations between objects or conditions. For example, it might be desired that A occur only if B occurs; or A must occur only if B and C occur simultaneously, etc. Symbolic logic expresses the conditional relationships between objects A, B, C, etc.

Conditions

1. First, it is obvious that A and B can be either present or absent. If A is present, we shall call it A. If A is not present, we shall call it $\overline{A}$, or *not* A.
2. Similarly, we shall refer to B or $\overline{B}$.

Connectives

1. In their relationship to still other objects, we might want some action C to occur if and only if A and B occur simultaneously together. We shall represent the connective *and* by a dot, as follows: (A•B), which means A *and* B.
2. We might wish C to occur if *either* A *or* B is present. We shall represent the connective *or* by the letter v —that is, A v B means A *or* B.

With these two simple conditions (*presence, absence*) and two simple connectives (*and, or*), we can proceed to develop the entire field of symbolic logic.

Symbols

The conventional symbols for the two basic conditions and connectives, together with symbols used to represent them, are given in Fig. 1.

Now we can read any logical statement:

(A•B) means A and B
(A•$\overline{B}$) means A and *not* B
($\overline{A}$•B) means B and *not* A
($\overline{A}$•B) v C means (B and *not* A) *or* C.

The question arises here: Why use the term "not"? Instead of $\overline{A}$, couldn't the term be neglected? It will be seen that the expressions A and $\overline{A}$ correspond to the binary signals 1 and 0 (or to the polarities + and —) in actual equipments designed to implement a given logic statement.

The next step is to show how simple equipments (the gates and buffers shown in Fig. 1) are used to represent any logical statement. The basic equipment used is the gate, or coincidence detector. If the problem has 3 variables, a 3-legged gate is used; if the problem has four variables a 4-legged gate is used (Fig. 2). We shall now see how complicated logical statements can be repre-

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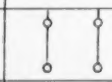
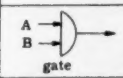
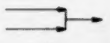
	Condition		Connective	
	true (assertion)	false, not (negation)	and	or
Written Symbol	A	$\overline{A}$	(A · B)	(A v B)
Schematic Representation				
Common Equipment Forms	positive d-c voltage (through feed) — pulse present	d-c voltage polarity reversal — no pulse	coincidence detector	summing circuit and limiter

Fig. 1. Symbols for the two basic conditions (presence, absence) and the two basic connectives (and, or). The gate is a circuit which requires both inputs to be present in order to produce an output; the buffer produces an output if either input is present.

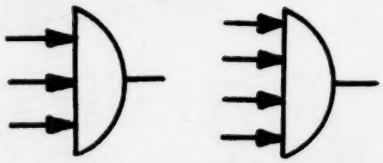


Fig. 2. Three-leg and four-leg "and" gates, or coincidence detectors. All inputs must be present before an output occurs.

sented by simple gates and suffers, assembled quickly with the aid of logic charts.

The Truth Table

The binary numbers 0 and 1 can be used also to represent the falsity (0) or truth (1) of a logical statement.

For example, if A is 1, then $\overline{A}$ (*not* A) must be 0.

If A and B are both 0, then neither A nor B is present, and 1 is entered in the *not* column in Fig. 3.

As A and B are not present, a 0 is entered in the *and* column in Fig. 3.

As *not* A and *not* B expresses the condition properly, a 1 is placed in the not-and column in Fig. 3.

The truth table in Fig. 3 expresses the truth or falsity of the various logical statements given (of which there can be many more) for each condition of the two variables A and B.

The Logic Chart

Ed Veitch of the Burroughs Company presented a chart method for describing the various combinations of logical statements in a 1952 meeting of the Association for Computing Machinery in Pittsburgh, Pa. This chart method permits rapid setup of equipment (gates and buffers) to meet any given logical statement.

A typical logic chart is shown in Fig. 4. Chart No. 1 shows the four possible combinations of 2 binary variables. Chart No. 2 shows the truth of A; Chart No. 4 shows $\overline{A}$; Chart No. 6 shows that only quadrant 4 represents (A•B); similarly only quadrant 1 represents ($\overline{A}$•$\overline{B}$), as shown by Chart No. 8.

The 3-Variable Logic Chart

All combinations of three two-state variables (A, B, and C) can be represented on a logic chart having eight squares (Fig. 5). The number of such possibilities is $2^{2^3} = 2^8 = 256$. The method for building up a simple logic statement in three variables, such as ($\overline{A}$•B) v C is also shown in Fig. 5. Note that the chart of ($\overline{A}$•B) v C is simply the graphical sum of Charts 4 and 5.

Setting up Equipment by Use of Chart

The two basic elements used in logical circuitry are the *gate* and the *buffer* (Fig. 1). The gate is simply a multiple-input circuit which develops an output only when *all* of its inputs receive a 1 signal. In other words the 3-legged *and* gate must have three 1 signals before it develops a 1 output.

The buffer is the *or* circuit. It is simply a multiple-input circuit which develops an output (1) when any of its several inputs receives a 1 signal.

Fig. 6 shows the circuitry required to set up the logic expression $\overline{A}$ (not A) when three variables (A, B, and C) are present. Each of the 8 separate gates refers to one of the 8 squares in Fig. 6—that is, square 1 corresponds to an *and* gate which gives a 1 output when its three inputs are $\overline{A}$, $\overline{B}$, $\overline{C}$; square 2 corresponds to an *and* gate which gives a 1 output when its 3 inputs are $\overline{A}$, $\overline{B}$ and C; square 3 corresponds to a 3-leg gate which gives a 1 output when its 3 inputs are $\overline{A}$, B and $\overline{C}$; etc.

Referring to Fig. 5, it is seen that the logic expression f = ($\overline{A}$•B) v C requires a 1 output from square 2 or 3 or 4 or 6 or 8—and the circuit for doing this is shown

4 Basic Conditions		not		and	or	not-and	not-or	(etc.)	
A	B	$\overline{A}$	$\overline{B}$	(A · B)	(A v B)	($\overline{A}$ · $\overline{B}$)	($\overline{A}$ v $\overline{B}$)	($\overline{A}$ · B)	(A v $\overline{B}$)
0	0	1	1	0	0	1	1	0	1
0	1	1	0	0	1	0	1	1	0
1	1	0	0	1	1	0	0	0	1
1	0	0	1	0	1	0	1	0	1
		1 = true 0 = false							

Fig. 3. Two 2-state variables can have four combinations (left). Truth table (right) express the truth (1) or falsity (0) of logical statements referring to the 4 basic conditions shown at left.

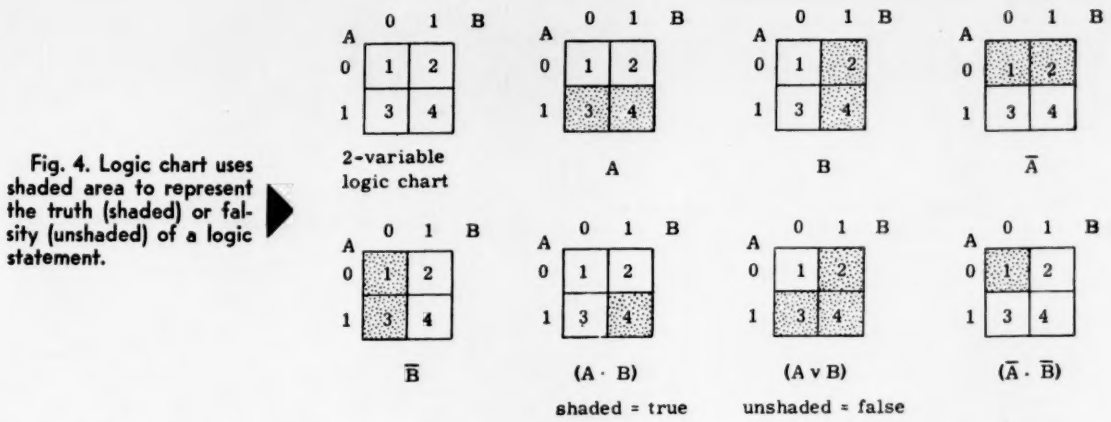


Fig. 4. Logic chart uses shaded area to represent the truth (shaded) or falsity (unshaded) of a logic statement.

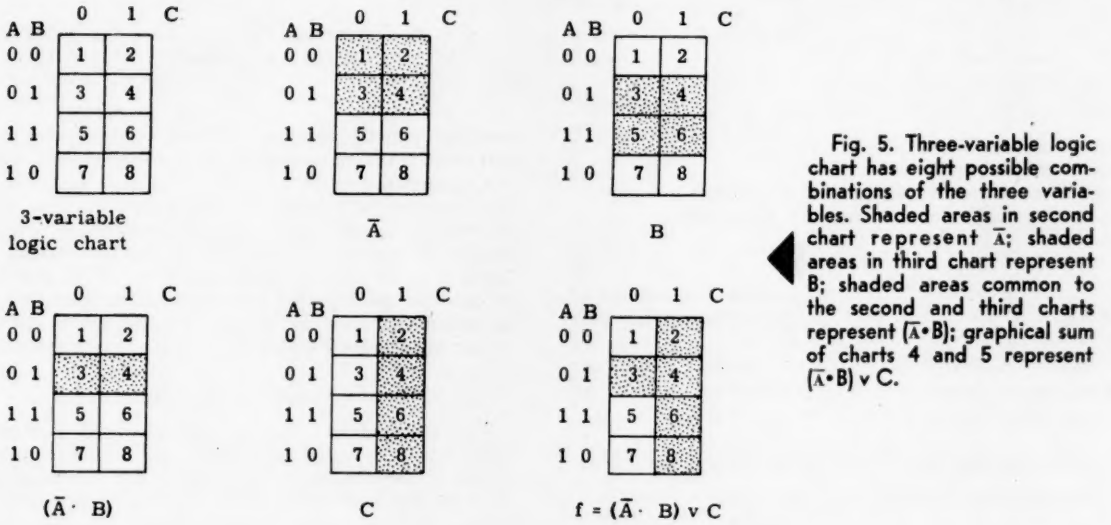


Fig. 5. Three-variable logic chart has eight possible combinations of the three variables. Shaded areas in second chart represent Ā; shaded areas in third chart represent B; shaded areas common to the second and third charts represent (Ā•B); graphical sum of charts 4 and 5 represent (Ā•B) v C.

in Fig. 7. Note that five *and* gates and one *or* gate (the buffer) is required.

Gates 2, 4, 6, and 8 give an output because of the C signal; gate 3 (and 4 also) gives an output because it satisfies the (Ā•B) requirement. The output is a signal that satisfies the (Ā•B) v C logic requirement. That is, the system produces an output when C exists, or whenever B exists simultaneously with A's nonexistence.

The 4-Gate Package

Note that the falsity of a statement can be represented simply by implementing the *unshaded* areas of the logic chart. Note also that the gates can be used to represent either the shaded or the unshaded squares of the chart—and in inverter can be used at the output to invert the signal to give an indication of either the truth or the falsity of the given logic.

Therefore, as there are only 8 squares in a logic chart involving 3 variables, and as either the shaded or unshaded squares can be used to implement the logic, it is obvious that *four* is the maximum number of gates required for any 3-variable logic. For example, in the case of Fig. 7, the logic could have been solved by use of gates 1, 5, and 7, and then inverting the output. For this reason, a 4-gate package can replace the 8-gate system of Fig. 7, and can represent all 3-variable functions. In fact, many 3-variable functions can be represented by using three or fewer gates.

Fig. 8 shows the 3C-PAC, a 4-gate package. In addition to being able to handle all functions of 3 variables, it can handle 51,358 functions of 4 variables, and many functions of 5 or more variables. As it is called on to establish either the truth or falsity of a given logic

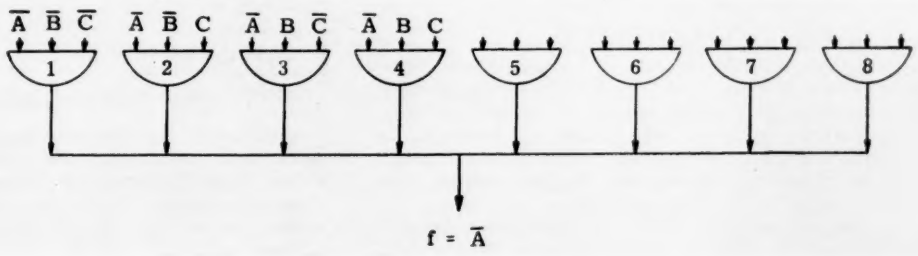


Fig. 6. Circuitry for setting up the logic of expression Ā.

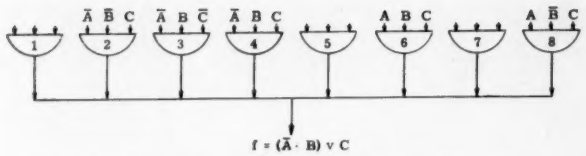


Fig. 7. Circuitry for setting up the logic of expression $(\bar{A} \cdot B) \vee C$.

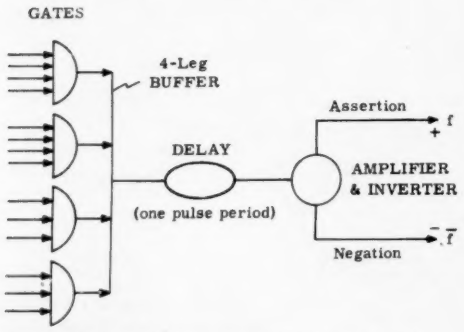


Fig. 8. The 3C-PAC gating package is a 4-gate package with inverter at output.

problem (whichever is more economical), it contains an inverter at the output, and also a 1-pulse-period delay unit, which will be described later.

Note that two of the four gates in the 3C-PAC are 4-leg gates; this extends the usefulness of the 3C-PAC to functions involving four or more variables.

Implementing any Function of Three Variables

The general rules for implementing *any* function of three variables with the 3C-PAC Gating Package are as follows:

1. Shade in the squares of the three-variable chart that represent the truth of the defined function f.

2. If the number of shaded squares is four or less, implement the function f by making the connections that correspond to the shaded squares. The positive output lead indicates the *truth f* of the function represented: the negative output lead represents the *false f*.

3. If the number of shaded squares is greater than four, implement the function f by making the connections that correspond to the unshaded squares (i.e., implement the *false f* of the function). The negative output lead represents the *truth f* of the described function; the positive output lead represents the *false f* of the function.

In Fig. 9, the 3C-PAC is shown set up to represent the same three-variable function $(\bar{A} \cdot B) \vee C$, treated in Fig. 7. Note that the three unshaded, or *false*, squares are implemented, and that the *true* function f is taken from the negation output.

Pulse Techniques

Many logical manipulations and computations must be performed at high speed. The 3C-PAC gating package thus has been designed to operate on pulses having a one-megacycle repetition rate. *Truth*, or assertion, is represented by a positive pulse on the assertion lead; *false*, or negation, is represented by the presence of a negative pulse on the negation lead.

In operation, synchronized pulse trains enter the gate legs, and pass through the gates and buffer to provide a

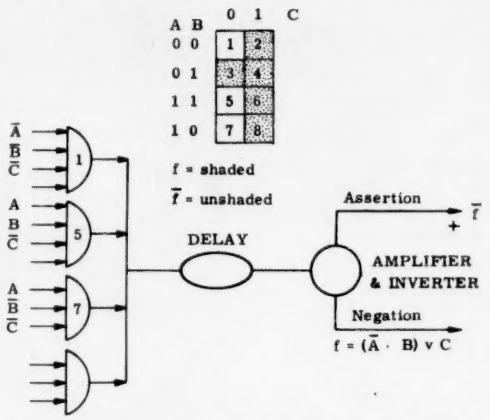


Fig. 9. Circuit for $(\bar{A} \cdot B) \vee C$, using the 3C-PAC gating package.

resultant output pulse train. One such pulse operation is performed each microsecond. The result of this operation is carried over for use during the next pulse period. The one-pulse-period delay is used to perform this carry-over function, and aids in the synchronization of pulse signals. It will be shown how the use of "serial" or "parallel" methods of instrumentation affect the time sequence of the different pulse operations. Accessory delay equipment is available when it is desired to hold an output pulse train for greater than one pulse period.

Binary Arithmetic

Digital computers, logical elements, and a host of other types of digital equipments are based on binary numbers because binary techniques are much simpler than decimal techniques. Binary is simpler than decimal for an obvious reason—there are only *two* basic numbers rather than *ten*. These two are commonly expressed as 0 and 1, and binary counting progresses as follows:

Decimal	Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

Just as each column or place in a decimal number represents a power of 10, each place in a binary number represents a power of 2. For example, the binary number 1010 means $1(2)^3 + 0(2)^2 + 1(2)^1 + 0(2)^0 = 8+2$ = decimal number ten.

The Double-Dabble System

A technique for binary-to-decimal conversion that is more rapid than conventional addition of each power of 2 has been developed by Edward Varnum (Barber-Colman Company). This system, called the *double-dabble system*, starts with the left-most bit and proceeds as follows:

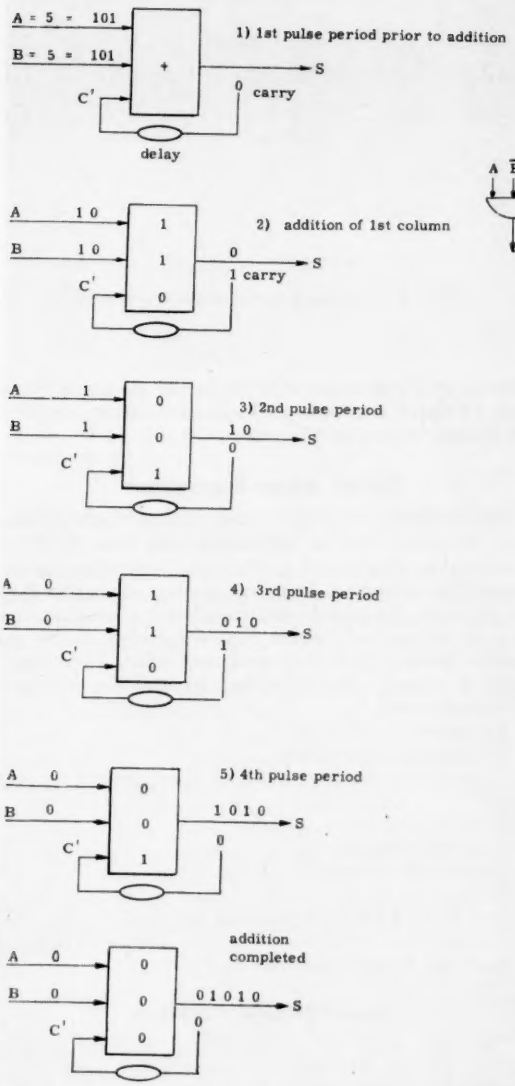


Fig. 10. Serial addition of two binary numbers 101 and 101.

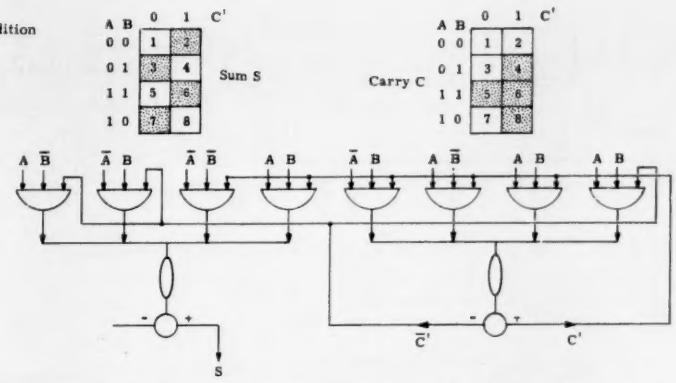


Fig. 11. Logic chart and circuitry for serial binary addition.

If the next bit is 0, double what you have.

If the next bit is 1, double what you have and add 1, which is called *dabbling*.

Let us convert the binary 1101 by double-dabble:

Starting at the left, first dabble 1 to get 3 because the next bit is 1; then double 3 to get 6; then dabble 6 to get 13. (As 1101 is 8 plus 4 plus 1, it is indeed 13.)

Conversely, to convert a decimal to a binary, the following technique is used:

First, divide the number by 2 and write down the remainder (which must be either 0 or 1).

Second, divide the halved number by 2 and write down the remainder. *All the remainders describe the binary equivalent.* For example: let us convert the decimal 27:

27/2 = 13 remainder 1. Write 1.
13/2 = 6 remainder 1, giving 11
6/2 = 3 remainder 0, giving 110
3/2 = 1 remainder 1, giving 1101
1/2 = 0 remainder 1, giving 11011
Thus 27 = 11011

With the double-dabble system we have a rapid manual method for converting a binary number to a decimal number, or vice versa.

Why Use Binaries?

There are two reasons for using binary techniques. One is that arithmetic operations are more simple in binary than in decimal. For example, addition in binary requires only two basic rules:

Rule 1; 1 plus 0 is 1
Rule 2: 1 plus 1 is 0, carry 1
Rule 2 can be restated:
1 plus 1 is 10.

With these rules let us add 5 and 5 in binary

101
101
1010, which is the binary equivalent of the decimal number ten (table 1).

The second reason for use of binaries is that the numbers 0 and 1 can be conveniently represented by available mechanical or electronic 2-state devices—switches, relays, gas tubes, signal polarity, etc. For example, an open switch might be used to represent a 0 with the closed position representing the 1; or a — signal might represent the 0 with a + signal representing the 1.

For these two reasons, binary arithmetic and binary techniques are of great and growing importance.

Binary Addition—Serial Method

The most common method for performing binary addition is called the *serial* method. By this method, two binary numbers, such as 101 and 101, are added by commencing with the right-hand column and progressing to the left, carrying a 1 to the next higher column when a (1 + 1) addition is indicated (Fig. 10). The two numbers A and B can be thought of as two pulse trains entering an adding device. The 0's represent *no pulse* and the 1's represent a pulse. The pulse trains A and B are synchronized so that corresponding columns enter the adding network precisely simultaneously. The two numbers "march" into the adder at the rate of one column per microsecond. As will be shown, the adding device must be a digital network arranged to perform the addition defined previously in this discussion (that is, 1 + 1 = 0, carry 1).

A "carrying" circuit supplies a third pulse, input C. The "carry" signals are fed back from the output

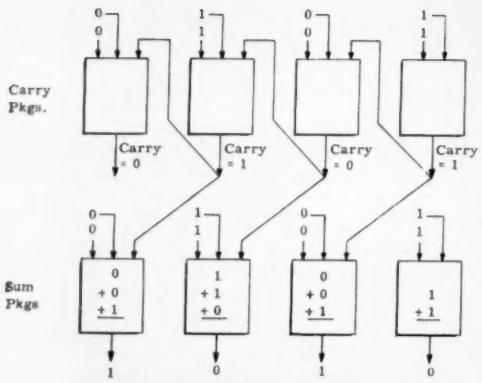


Fig. 12. Parallel binary addition.

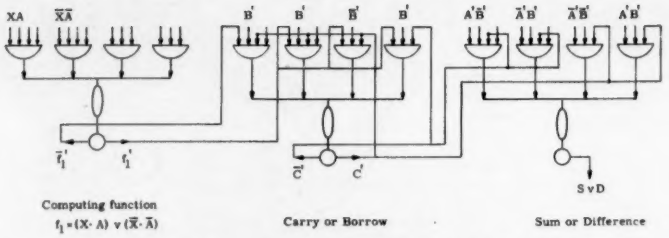


Fig. 13. Combined serial adder-subtracter.

through the one-pulse-period delay. The "carry" digit is thus added to the next higher-order column, and is indicated with a prime sign (C′) to show that it is generated one-pulse-period earlier than the A and B inputs. Fig. 10 shows how the two digital numbers A and B are added in four pulse periods.

Serial-Addition Implementation

A=Incoming binary digit of augend
B=Incoming binary digit of addend
C=Carry digit determined by addition performed one-pulse-period earlier
S=Sum digit of column being added

A carry pulse will appear whenever any *two* or *three* of the 3 variables (A, B, C) are present.

The sum will be 1 whenever *one* or *three* of the inputs are present (because the sum is 0 when two "1" inputs are present).

These two statements of fact can be written as two logical expressions, as follows:

$$C=(\overline{A}\cdot B\cdot C')\ v\ (A\cdot\overline{B}\cdot C')\ v\ (A\cdot B\cdot\overline{C}')\ v\ (A\cdot B\cdot C')$$
$$S=(A\cdot B\cdot\overline{C}')\ v\ (\overline{A}\cdot B\cdot\overline{C}')\ v\ (\overline{A}\cdot\overline{B}\cdot C')\ v\ (A\cdot B\cdot C')$$

Set up in the form of logic charts, the Carry and Sum functions appear as shown in Fig. 11. These adding functions are easily implemented using two 3C-PAC gating packages, interconnected as shown.

Binary Addition—Parallel Method

The serial method of addition requires as many pulse periods of time as there are columns of digits to be added. If a faster addition is required, the *parallel* method (Fig. 12) can be used.

The parallel method requires as many sets of Carry and Sum 3C-PACs as there are columns to be added. The two numbers to be added enter the parallel adding system of Fig. 12 repeatedly for as many pulse periods *as there are carries*. The correct Sum then will appear as shown. The parallel addition system of Fig. 12 can be implemented with eight 3C-PAC gating packages. Signal leads of Carry and Sum packages are interconnected in the manner shown in Fig. 11.

Serial Adder-Subtracter

For flexibility in binary computation, both addition and subtraction can be performed with three 3C-PACs, connected as shown in Fig. 13. Serial subtraction is performed by setting up logic expressions similar to those for addition. An additional add-subtract command function X is required, which causes addition to be performed when a pulse is present, and subtraction when a pulse is absent. The variables required for the serial adder-subtracter are:

A=augend or minuend
B=addend or subtrahend
C=carry or borrow (delayed from preceding pulse period)
X=add command
$\overline{x}$=subtract command
D=subtract command
S=sum
f=(X•A) v ($\overline{x}$•$\overline{A}$) computing function

Using these variables, the serial adder-subtracter of Fig. 13 can be achieved with 3C-PACs.

Four-Variable Functions

The logic chart for a four-variable function is shown in Fig. 14. On this chart all possible functions of four variables can be defined. There are 65,536 such combinations, 51,358 of which can be implemented by a single 3C-PAC. To implement a separate square of this chart would require one 4-leg gate. Implementing all squares separately would thus require sixteen such gates. To lessen the number of gates required, however, it is possible to represent "blocks" of adjacent squares with a single gate. In defining such blocks, the first and last columns of the chart and the top and bottom rows can be considered adjacent.

If shaded or unshaded squares are grouped together they can be implemented as follows: (a) *Eight* adjacent squares forming a 2 x 4 rectangle can be represented by a 1-leg gate. (b) *Four* adjacent squares forming either a 2 x 2 or a 4 x 1 rectangle can be represented

A	B	0 0	0 1	1 1	1 0
		C			
		D			
0	0	1	2	3	4
0	1	5	6	7	8
1	1	9	10	11	12
1	0	13	14	15	16

Fig. 14. Logic chart for four variables has 16 squares.

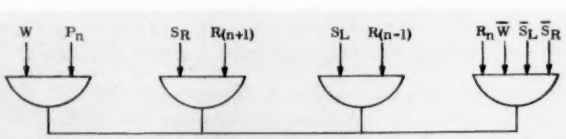


Fig. 15. A binary digital shift register.

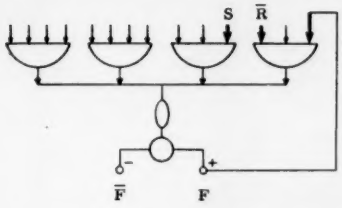


Fig. 16. Using the 3C-PAC as a flip-flop.

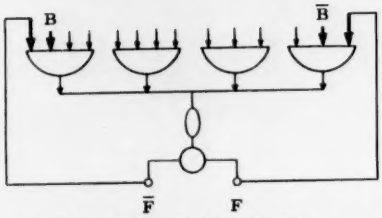


Fig. 17. Binary flip-flop that changes state each time a B pulse is applied.

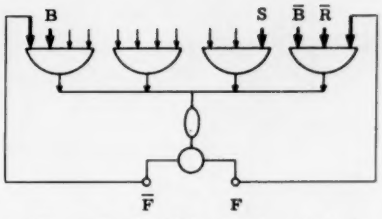


Fig. 18. Bistable device that is turned on by a set pulse, turned off by a reset pulse, and which changes state on a B pulse.

by a 2-leg gate. (c) *Two* adjacent squares sharing the same row or column can be represented by a 3-leg gate. (d) Remaining single squares require a 4-leg gate for representation.

Multiplication, Division, Function Generation, Calculus Operations

Nearly all other mathematical operations can be reduced basically to addition and subtraction operations, and implemented with 3C-PACs as described previously. Accessory operations may be required, such as register shifting.

Multiplication of decimal and binary numbers by register shifting and addition is standard technique. Binary division by the conventional method of trial multiplication (or addition) and subtraction is also standard. Such step-by-step computing programs are easily implemented with 3C-PACs and appropriate pulse delays.

Function generation is performed by implementing an algebraic series expansion of the desired relationship. *Integration and differentiation* are handled by binary numerical methods. These involve basic addition and subtraction operations, programmed by the logical interconnection of 3C-PACs.

Shift Registers

Registers serve as repositories for digital information. While storing such digital information, it is often desired to shift the time sequence or relative space position of the pulses. The functions of shift registers may thus include serial read-in and read-out, parallel read-in and read-out, shifting of information to right or left, etc. These operations, which can be performed with 3C-PACs, are used in parallel-to-serial and serial-to-parallel code conversion, storage of information, binary arithmetic operations, conversion of pulse information between low-speed and high-speed systems, etc.

The variables involved in register shifting include:

W=parallel read-in command

P=external information to be read-in

R_n=n^{th} bit of stored information

S_R= shift *right* command

S_L=shift *left* command

For serial read-in and read-out, the required shifting function is $(S_R \cdot R_{(n+1)})$ for the n^{th} stage. For parallel read-in, the shifting function is $(W \cdot P_n)$; for parallel read-out, the output of each shifting stage is available to drive several gate inputs. For shifting information to the right, the function $(S_R \cdot R_{(n-1)})$ is used; for shifting to the left, $(S_L \cdot R_{(n+1)})$ is used. That is, if a digit is stored in the third position, a shift left command causes the digit to be stored in the second position; a shift right command causes this digit to be stored in the fourth position. The gates of a typical shift register stage are wired as shown in Fig. 15. The fourth gate $(R_n \cdot \overline{W} \cdot \overline{S}_L \cdot \overline{S}_R)$ causes the information to circulate and be stored, or "memorized," until it is desired to replace it with new information.

Other uses for 3C-PACs include the translation of codes, such as the conversions of teletype code to IBM code, Gray code to binary code, decimal code to binary code. The packages can be used also for effecting flip-flop and similar operations.

Flip-Flop

The flip-flop, shown in Fig. 16, is a familiar bistable element. The simplest form of a flip-flop is one that is turned "on" by applying a pulse S(set pulse) and turned "of" by applying a pulse R (reset pulse); i.e., once the flip-flop has been turned on by the set pulse, it should remain on (true) until it is turned off by the reset pulse. Conversely, it should remain off (false) until it is turned on again by a set pulse.

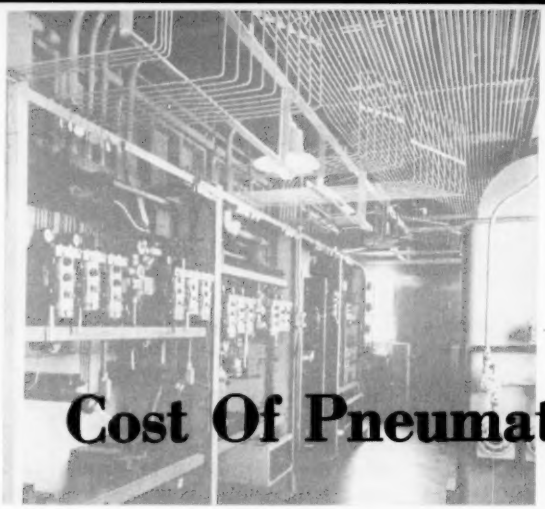
If symbolic logic is employed, the expression for this device is $S \vee (\overline{R} \cdot F)$, where S is the set pulse, F is the plus output of the flip-flop, R is the reset pulse, and $\overline{R}$ is used to mean "no reset pulse." Hence, the statement $S \vee (\overline{R} \cdot F)$ says that this device shall have a true output after it receives a set pulse and shall continue to have a true output until a reset pulse is received. If the statement is examined, it can be seen that the S pulse creates the true pulse F and that the term $(\overline{R} \cdot F)$ maintains this true state. Whenever an R pulse is received, the latter term becomes false, causing the entire statement to be false, hence turning off the device. Thus, a flip-flop has been created. The flip-flop connections used on a 3C-PAC are shown in Fig. 16.

Binary Flip-Flop

A binary flip-flop (Fig. 17) is a stable device that changes state each time an input pulse B is applied. The symbolic logic statement for this $F' = (B \cdot \overline{F}) \vee (\overline{B} \cdot F)$. The symbol F′, read "F delayed one pulse period," distinguishes the output of a 3C-PAC from its inputs (which occur one microsecond earlier). The characteristic of a binary flip-flop is that if it is off (F′ false and $\overline{F}'$ true), a pulse B will turn it on (make F′ true). The flip-flop will remain on $(\overline{B} \cdot F$ true) until another pulse B is received. Conversely, if the device is on (F′ true and $\overline{F}'$ false), a pulse B will turn it off until another pulse B is received.

An extension of the flip-flop and binary flip-flop, shown in Fig. 18, is a bistable device that is turned on by a set pulse, turned off by a reset pulse, and has its state changed by application of the B pulse. The symbolic logic statement for this is $F = S \vee (B \cdot \overline{F}) \vee (\overline{B} \cdot \overline{R} \cdot F)$

In similar manner, the gating package can be used as a binary counter, forward-backward counter, binary adder, binary subtracter, etc.



Cost Of Pneumatic Control Systems

E. I. THOMAS
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Carbide and Carbon Chemicals Co.

HISTORICAL REVIEW

After World War II, spiraling costs for copper and labor associated with the installation of miles of instrument tubing were placing pneumatic instrumentation in an unfavorable cost position vis-a-vis the newer electronic systems.

The Instrument Division of Carbide & Carbon Chemicals Company, South Charleston, W. Va., was one of the few large instrument users in the country that had its fingers on the pulse of this situation. Chief Instrument Engineer E. I. "Tommy" Thomas had, with great foresight, accumulated complete costs that pinpointed the growing costs of pneumatic instrument installation. Thus, in 1951, Tommy began an investigation of alternatives to copper and metal tubing.

Plastic tubing appeared to be an attractive alternative. It was economic, inert to most industrial atmospheres, and strong enough for the pressures involved in instrument work. But, it was soon discovered that the imperfections of commercial grade plastics then available prevented the tubing from meeting the rigid requirements for reliability that are the first consideration of the industrial instrument field.

This might have ended the story for most engineers. But Thomas, in cooperation with Samuel Moore & Co., embarked on a program for obtaining plastic tubing of true instrument quality. Their success after intensive research, development and full field tests was reported in 1954 (See *I&A*, October 1954). Constant improvements of plastics and their application and fabrication makes Tommy's pioneering of plastics more valuable today than ever before. In the past 2½ years, better plastics manufactured by the resin suppliers insure longer life, higher temperature limitations, higher burst pressures for the same size tube, and better chemical resistance. Wider usage of plastics in instrumentation has encouraged manufacturers to produce more colors of tubing and more sizes in longer lengths, and to control the manufacture even more closely than ever before.

This article brings this history up to date. It shows how the costs for a complete instrument system are calculated in detail—by the man who has done more than any other single worker in the field to "system engineer" the all-important pneumatic-control-system installation-cost problem.

Table 1—Control Room and Panel Costs

Control Room	$600/linear Foot
Panel Framework	
Material	$5.92/ft
Labor	$1.78/ft
Total	$7.70/ft
Panelboard	
Material	$23.72/ft
Labor	$12.00/ft
Total	$35.72/ft
Panel Cutouts	
Large	$7.50 each
Small	$3.50 each
Mount Instruments	$10.00 each

Table 2—Air Header Costs

Main Header Fabrication	
Material	$1.50/ft
Labor	$ .85/ft
Branches	
Valve (metal)	$2.45 each
Valve (plastic)	$1.65 each
Labor	$1.15 each
Total cost/ft with 3 branches/ft	
Metal	$14.85/ft
Plastic	$12.45/ft

Table 3—Tubing Cost per Linear Foot, Installed

	Material Inc. Fittings	Labor	Total Cost
1/4" O.D. Copper	.15	1.20	1.35
3/8" O.D. Copper	.20	1.35	1.55
3/8" O.D. St. Steel	1.55	1.75	3.30
3/8" O.D. Plastic Over Steel	.65	1.53	2.18
2" Conduit Insulated	.95	2.10	3.05
3" Conduit Insulated	1.54	3.80	5.34
4" Conduit Insulated	2.09	4.20	6.29
1/4" O.D. Polyethylene in Vinyl Sheath			
19 Tubes (2")	.067	.047	*.27
57 Tubes (3")	.067	.047	*.21
76 Tubes (4")	.067	.047	*.20

*Includes Conduit Cost Reduced to Linear Footage of Polyethylene Tubing

TODAY the dollar sign is attached to every job. In order for our instrument engineers at Carbide to correctly estimate the many different jobs we have, we have developed a system of unit cost figures for large instrument installations as well as smaller ones. By using the proper unit cost, it is possible to arrive at a close estimate for instrumentation for any given job.

Control Room Unit Cost

Most of our control rooms are built as a one-story structure, 20 feet in width, with the length varying according to the amount of instruments to be applied to the process. If we reduce the cost of such a building to a linear foot basis, which is a little unorthodox, we arrive at a figure of $600 per linear foot.

Panel Unit Cost

Once we have the control room, we can elect to have our panels fabricated by panel manufacturers or, by using a type of structure common with us, we can erect them in the field. The framework which we use is made of Unistrut or equivalent, and, as erected into panel structures, has an average height of seven feet.

The unit cost for the *material* to erect this framework is $5.92 per linear foot and the labor cost is $1.78 per linear foot, giving a total of $7.70.

Standard-size steel panels for mounting instruments are used. These panels are 24" by 26" for the bottom and two center panels (where the instruments are mounted) and 24" by 13" for the top panel (where pressure gages and auxiliary equipment are mounted). The cost of panels per linear foot is $23.72 and the labor for mounting these panels to the framework averages $12 per linear foot. Cutouts for mounting the large-case-type instruments run $7.00; $3.50 for the small miniature type.

The cost to mount either large or small instruments on the panel (no piping) averages $10 per item. The cost data for the control room and panel are given in table 1.

Air Header Costs

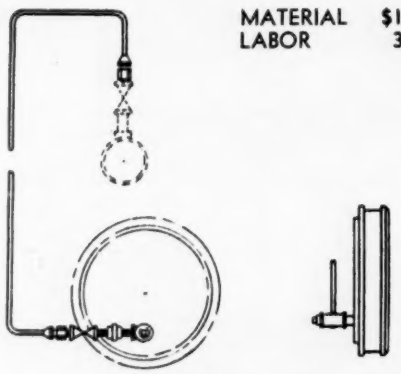
Air supply headers behind the panelboards are usually constructed of 1½" standard brass pipe, which is drilled and tapped for ⅛" pipe connections at an equal spacing of 4" between tapped holes. When we use metal tubing to connect the instrument items to this air supply, the shutoff valve on the header costs $2.45 each and the material for fabricating the headers is $1.50 per foot. Labor costs an average of $1.15 to make each branch air connection and 85 cents per foot to fabricate the main header.

If we use plastic tubing for the air supply to the instruments rather than metal tubing, the valve cost is reduced to $1.65 each while the labor cost remains the same. Combining all of the material and labor cost to fabricate the header, we have a figure of $14.85 per foot for metal tubing and $12.45 for plastic tubing (table 2).

Tubing Costs

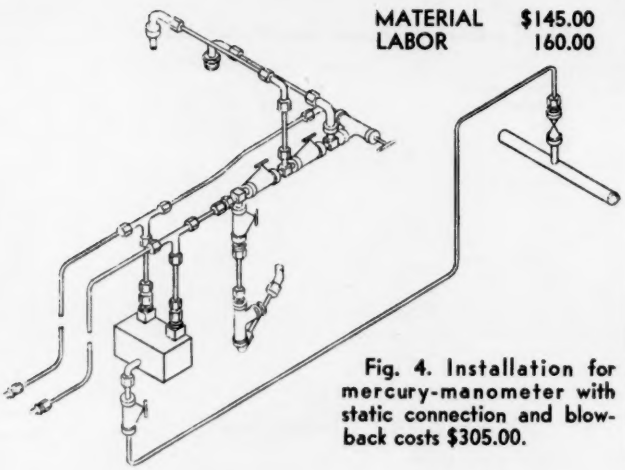
At the time this analysis of instrument cost was made, ¼" O.D. copper tubing cost 8 cents/foot, and fittings for this type tubing averaged 12 cents each, giving us an average material cost of 15 cents per foot, and the labor for installing is $1.20 per foot (see line 1, table 3).

For process leads to instruments, it is necessary that the tubing used be of a material that will withstand corrosive action due to the process and, in addition, be capable of withstanding external corrosion. In many cases atmospheric corrosion is more severe than that due to the process. If copper can be used for process leads, the cost is 12 cents per foot for ⅜" O.D. size with an average fitting cost of 14 cents, which gives an average material cost of 20 cents per foot. The labor to install ⅜" O.D. size copper tubing is $1.35 per foot (see line 2, table 3).



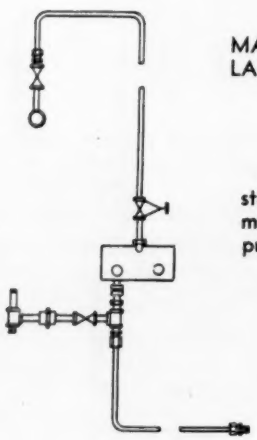
MATERIAL $14.00
LABOR 36.00

Fig. 1. Static-pressure installation costs $50.00.



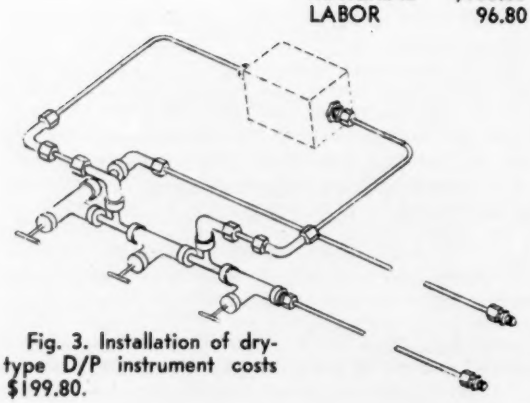
MATERIAL $145.00
LABOR 160.00

Fig. 4. Installation for mercury-manometer with static connection and blowback costs $305.00.



MATERIAL $72.00
LABOR 60.00

Fig. 2. Installation of static-pressure instrument with blowback or purge costs $132.00.



MATERIAL $103.00
LABOR 96.80

Fig. 3. Installation of dry-type D/P instrument costs $199.80.

If, however, the process requirements are such that stainless-steel tubing is required, then 3/8" O.D. stainless steel tubing costing 54 cents per foot and fittings averaging $2.50 gives us an average material cost of $1.55 per foot. Normally stainless steel is much harder to work than any other type tubing used for instrument work, so the labor cost per foot to install it is $1.75 (see line 3, table 3).

In the past we have had applications where neither copper nor stainless steel would stand atmospheric corrosion, so plastic-covered steel was developed. This material is fully annealed, seamless SAE 1010 steel with a "Vinylite" extruded protective cover, costing an average of 32 cents per linear foot for 3/8" size. Cadmium-plated steel fittings average $1.00, including the protective tape which is used to seal the fitting once it is made tight. The average material cost per linear foot is 65 cents, and the labor cost for installing is $1.53 per foot (see line 4, table 3). This tubing, properly installed, will last for many years. We have one such installation that has more than 10 years of service where, previously, stainless steel would not last more than one year.

Table 3 tabulates the average material and labor cost for installing tubing of different materials. Note that our figures place the total cost for material and labor for

Table 4—Instrument Installation Costs

	Material	Labor
Static Pressure Hookup (Fig. 1)	$14.00	$36.00
Static Pressure with Blowback (Fig. 2)	$72.00	$60.00
Dry-type D/P Instrument (Fig. 3)	$103.00	$96.80
Manometer with Blowback (Fig. 4)	$145.00	$160.00
Close-coupled D/P Cell (Fig. 5)	$103.00	$125.25
D/P Cell with Blowback (Fig. 6)	$132.00	$189.60
Control Valve with Positioner (Fig. 7)	$20.00	$55.00
Locally-mounted Controller (Fig. 8)	$30.00	$68.50
Blind Transmitter (Fig. 9)	$35.00	$77.00

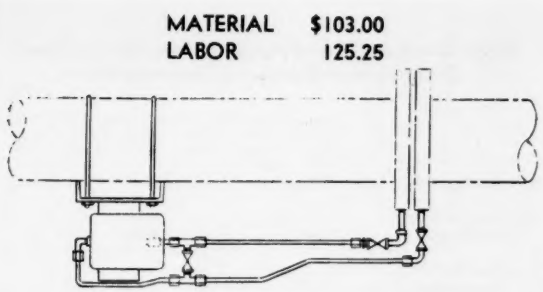


Fig. 5. Installation of close-coupled D/P cell costs $228.25.

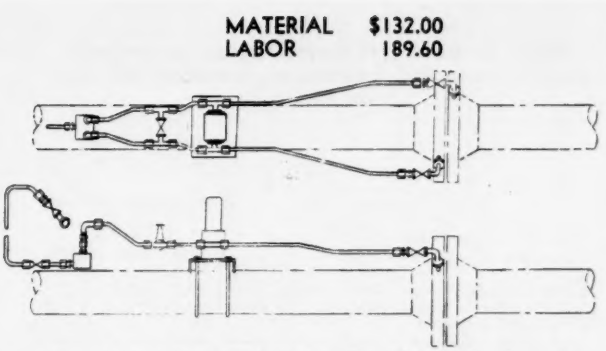


Fig. 6. Installation of D/P cell with blowback costs $321.60.

¼" O.D. copper tubing at $1.35 per foot, ⅜" O.D. copper tubing at $1.55, ⅜" O.D. stainless steel at $3.30, and ⅜" plastic covered steel at $2.18, while polyethylene tubing installed in an insulated conduit averages 23 cents/foot, including the material and labor to install and insulate the conduit.

Instrument Installation Costs

Unit cost figures for installing a direct-connected pressure instrument are $14.00 for material and $36.00 for labor (Fig. 1). Labor is based on a figure of $6.33 per hour, which, of course, includes all overhead. If we add an inert gas purge to this installation, the material cost goes up to $72.00 and the labor to $60.00 (Fig. 2).

For dry-type differential-pressure-type instruments, the material costs are $103.00 and labor $96.80 (Fig. 3). Again, if we add purge to this, the material costs are $145.00 and the labor is increased to $160.00 (Fig. 4).

For locally mounted transmitters such as differential pressure, the material costs are $103.00 and the labor cost is $125.25 (Fig. 5). With purge, the material cost will be $132.00 and labor jumps up to $189.60 (Fig. 6).

To connect the instrument air supply to a valve positioner via 20 feet of tubing, the material cost is $20.00 and labor is $55.00 (Fig. 7).

Remotely located temperature instruments will average 75 cents per linear foot to install the capillary tubing. Now, if we consider temperature transmitters instead of remotely located temperature instruments, the labor cost to mount the transmitter to the thermowell head is only $6.33.

The air piping required for a locally mounted controller or transmitter with an average of 20 feet of tubing for the air supply (and no connecting tubing from the transmitter or controller) costs $30 for material and $68.50 for labor (Fig. 8)*. Now, if instead of an indicating transmitter we install what is commonly referred to as a blind transmitter, the material cost increases to

*Why does Fig. 8 cost more than Fig. 7? The figures given for this particular type of installation consisted of an average number of installations of several different types of instruments, some of which require auxiliary equipment such as strainers on the air supply and air leaving the instrument and, occasionally, pressure gages which do not show in the figure. The over-all average for any instrument requiring this particular air hook-up came out to be higher than that for a valve positioner, which, on the surface, would appear to be identical. Also, strange as it may seem, whenever an instrument fitter actually connects up to an instrument proper rather than to a positioner on a motor valve, we find that he spends more time in trying to make the job neater and, apparently, wastes more material in trying to get the proper bends for the sake of appearance.

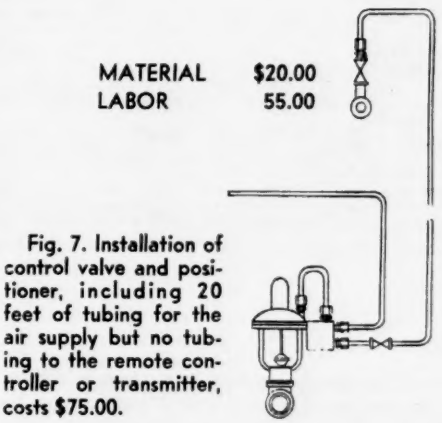


Fig. 7. Installation of control valve and positioner, including 20 feet of tubing for the air supply but no tubing to the remote controller or transmitter, costs $75.00.

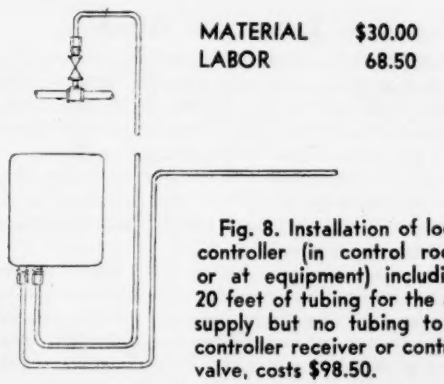


Fig. 8. Installation of local controller (in control room or at equipment) including 20 feet of tubing for the air supply but no tubing to a controller receiver or control valve, costs $98.50.

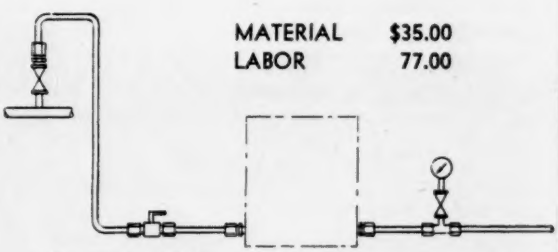


Fig. 9. Installation of a blind transmitter at the process point costs $112.00 (including 2½" dial size gage).

Table 5—Cost for System Using Large-Case Direct-Connected Instruments Located 100 feet from Process

	Instrument Cost	Connections to Instrs. at Panel	Air Tube ¼" O.D. Cu.	Connecting Leads 100 ft. Lead. Copper	St. Steel	Plastic over Steel
5 Flow Recorders-Process Material in Leads	1150	999	——	1550	3300	2180
5 Flow Recorders-Purge	1150	1525	——	1550	3300	2180
5 Temperature Recorders 100 ft. Capillary	1445	375	——	——	——	——
5 Liquid Level Recorders—Purge	1150	1525	——	1550	3300	2180
15 Pressure Controllers, Flow Recorders-Purge	8737	5325	2452	4650	9900	6540
20 Temperature Controllers 100 ft. Capillary	13070	1500	3270	——	——	
27 D.M.V.'s with Positioners	8937	——	2025	——	——	——
8 D.M.V.'s without Positioners	2088	——	——	——	——	——
Total	37,727	11,249	7747	9300	19,800	13,080

Table 6—Cost for System Using Large-Case Transmitter-Receiver Instruments

	Instrument Cost	Process Tube at Trans.	Air Tubing Cost-¼" O.D. Copper Transmitter	Field Tubing	Control Room	Total
20 1 Pen Recorders	2700	——	——	——	——	——
15 2 Pen Recorder Controllers	7612	——	——	2025	710	——
20 1 Pen Recorder Controllers	9950	——	——	2700	1080	——
15 Diff. Press. Transmitters. Direct Connected	3600	2997	1680	2025	710	——
15 Diff. Press and Pressure Transmitters-Purge	5872	4575	1680	4050	1420	——
25 Temperature Transmitters	3668	*158	2800	3375	1350	——
27 D.M.V.'s with Positioners	8937	——	——	2025	——	——
8 D.M.V.'s without Positioners	2088	——	——	32	——	——
Total	44,427	7730	6160	16,232	5270	
*Mounting Transmitter to Well Head						27,662

$35.00 and the labor costs to $77.00 (Fig. 9). With such unit costs, we can then arrive at a good figure for the installed cost of any instrument system.

Total System Cost Estimates

Let us develop an installed cost for an instrument system which might involve the measurement of 70 different variables with half of the applications controlled. The instruments are: 20 single-pen recorders (10 measuring flow, 5 temperature and 5 liquid level); 15 two-pen recording-controlling instruments (one pen controlling, the second pen recording) for flow and pressure; 20 single-pen temperature controllers; and 35 motor valves, 27 of which have valve positioners.

Three cost analyses are given—(1) where the instruments are remotely located from the process by an average of 100 feet and are direct-connected to the process, (2) next for transmitters and large-case pneumatic-receiver-type panel instruments, and (3) for miniature-type instruments with blind transmitters.

System A

The first system we will designate as A. Table 5 shows the cost of such an installation, broken down into cost for instruments, connections at instruments, air piping from the controllers to the control valve (using ¼" O.D. copper tubing), and connecting leads from the control room to the process (using either copper, stainless steel or plastic-covered steel).

System B

System B (Table 6) gives the cost of the transmitter and large-case pneumatic-receiver-type installation. Note that the process piping to the transmitters gives a smaller total figure for *process tubing* than was required for System A.

System C

Table 7 shows System C, which covers the blind transmitter and miniature-receiver-type instruments wherein polyethylene tubing is used for all instrument air service from the instruments on the panelboard to the remotely located junction box (from which ¼" O.D. copper is used and which averages 20 feet per air line). Incidentally, this system is based on the use of six 19-tube bundles pulled into conduit, thereby providing nine spare tubes for future additions to the control system, plus six pairs of wires for sound-powered telephone, one pair of which is a part of each plastic-tube bundle.

A summary of the three preceding tables is given in Table 8. Note that for Systems A and B a control room 80′ long and costing $48,000 is required, while in the cost of System C only a 20′ long structure is needed, which costs $12,000. The instruments and valves for System C cost slightly more than for either A or B.

Installation Cost Figure Per Major Item

An interesting way of presenting the instrument cost figures for these systems is to take the total cost of the installation, subtract the actual instrument cost, and then divide by the number of major instrument items to arrive at an *installation cost figure per major item*. For System A, using copper tubing and 90 major instrument items, this figure is $895. For stainless steel tubing, it is $1,011, and for plastic covered steel tubing, it is $936.

For System B, where we have 145 major instrument items, this figure is $604 per item. Now, in the case of System C with 145 instrument items, the figure is $223 per major item.

Table 7—Cost for System Using Small-Case Instruments and Plastic Air Tubing

	Instrument Cost	Process Tube at Trans.	Air Tubing Cost: Plastic Tubing Air Sup. and Clk.	Plastic Tubing Inc. Conduit**	Copper-Junct. Box to Instr.
20 1 Pen Recorders	3600	——	46	——	——
15 2 Pen Recorder Controller	8250	——	69	345	——
20 1 Pen Recorder Controller	10,200	——	92	460	——
15 Diff. Press. Transmitter Direct Connected	3600	2997	——	345	1680
15 Diff. Press. and Pressure Transmitter-Purge	5872	4575	——	690	1680
25 Temperature Transmitter	3668	*158	——	575	2800
27 D.M.V.'s with Positioners	8937	——	——	——	2025
8 D.M.V.'s without Positioners	2088	——	——	——	——
Total	46,215	7730	207	2622	8185
Total Plastic	——	——	——	2829	——
Total Metal	——	——	——	——	8185

*Mounting Transmitter to Well Head
**From Instr. to Junction Box

Table 8—Comparison of Totals for 3 Basic System Types

	A Direct Connected			B Large Case Pneu. Rec. Trans.	C Small Case Pneu. Rec. Trans.
Control Room	48,000			48,000	12,000
Instruments and Valves	37,727			44,427	46,215
Panel Frame	432			432	108
Panels and Cutouts	1745			1745	525
Mounting Panels and Instruments	1222			1222	718
Air Header	815			815	174
Process Tubing at Panel	11,249			——	——
Process Tubing at Trans.	——			7730	7730
Air Tubing Metal	7747			27,662	8,185
Air Tubing Plastic	——			——	2,829
Process Tubing	Copper 9,300	St. Steel 19,800	Plastic Over Steel 13,080		
Totals	Copper 118,237	St. Steel 128,737	Plastic Over Steel 122,018	132,033	78,484

Cost of Air

The question might be raised regarding the cost of installing an instrument air system for a chemical plant. As it is not likely that only one process exists within the plant, we have based our instrument air installation figures on a delivered volume of 3,000 cubic feet per minute, which is a volume far in excess of the requirements for any of the instrument systems analyzed. This air system is complete with compressor, aftercooler, alumina traps and the necessary piping required to deliver this utility to the units. Such a system is estimated to cost $120,000 and, if it is amortized over a 20-year period (which most capital equipment is), we arrive at an amortization figure of 3 mills per 1,000 cubic feet.

Using the current operating cost figures for compressor stations delivering this type utility, we find that it is 4.8 cents per thousand cubic feet of air, and this added to the amortization cost gives us a total of 5.1 cents per thousand feet of clean, dry air. Now, if we take System C, which has 27 valve positioners as air-using items, 55 transmitters of various types, and 35 controllers, or a total of 117 air-using items, and assume air usage at a maximum of one cubic foot per minute, we find that it costs $8.50 per day for this requirement. Actually, this cost is less than $4.00 per day because none of these items under normal conditions will use more than ½ cubic foot per minute.

Maintenance Costs

Of course, no cost analysis is complete without some idea of what is required to maintain these instruments. From accounting records we learned that our field men had 126,747 service calls last year. This, calculated on the total man hours available, gives a cost of $5.38 for each field service call. Many of these calls are found to be due to process upsets rather than instrument troubles, and it is only because the instrument shows a condition existing different from normal that the operator suspects instrument trouble.

We also calculated the cost of overhauling an instrument in our main instrument shop and found this to be $11.70 per major item. Incidentally, major items include control valves. This cost, of course, should be higher than for field service calls because all major items that are in need of complete overhaul, as well as those that have to have parts fabricated, are brought to the shop. Now, if we wish to determine the total service cost appropriated to each major instrument, including all over-head cost, we arrive at a figure of $49.60 per instrument per year. This is calculated by using the total of 157,711 man hours available, plus instrument supervision and overhead cost, divided by the total number of major instrument items in the plant, which was 19,135. (It should be stated that a number of these instruments have been installed for a period of ten to fifteen years.)

Another interesting figure for comparison is derived from the number of instrument items installed or moved by our instrument fitters. Taking the number of items which they handled, divided by the total cost of installers' time plus overhead, we find that for the South Charleston plant it costs $240 per major instrument item. This, of course, covers mostly the large-case instruments since the plant is one that has been in operation for many years and does not lend itself readily to the use of miniature instruments without a complete revamping of the process being undertaken. When you consider that the cost of the building structure is not included in this figure, it compares very favorably with those given previously for new construction jobs.

To summarize, the pneumatic instrument can be installed for $220 and can be operated each day at a cost of approximately 3.5 cents for air and serviced for 13.5 cents, thus giving a total daily operating cost of 17 cents per instrument.

D. L. SCHACHER
Tel-Instrument Electronic Corp.

Vibration Calibrator

—AN EXCLUSIVE DISCLOSURE—

Vibration measurement can involve three variables—displacement, velocity, and acceleration. Displacement is measured where the actual amplitude of motion of a part is important; velocity measurements are generally used in noise problems; acceleration measurements have importance for problems where mechanical failure is involved. This exclusive disclosure presents an electronic micrometer for displacement measurement.

ACCURATE MEASUREMENT of vibration over wide frequency ranges and down to small magnitudes is becoming increasingly important. Electrical, mechanical, and optical techniques have been used, but by far the most common method is to convert the vibration into electric signals. Three types of transducers are available, depending on whether displacement, velocity, or acceleration is the basic quantity to be measured. For sine-wave vibrations at a known frequency, conversion between the three measurements is simple.

Most transducers in use are electromechanical generators (such as a piezoelectric crystal or a coil moving in a magnetic field) that convert mechanical forces to electrical output. Unfortunately the mechanical portion of such systems is prone to mechanical resonances, so that it is necessary to check these pickups for flatness over the entire frequency band of interest.

Various techniques have been introduced for calibration. In one method, a stroboscopic light "stops" the motion of the transducer pickup[1]; in another, use is made of a reciprocity calibration in which one transducer is used as a vibration generator and a second as a pickup; then the roles are reversed[2]. This technique, like most other methods of calibration, has two disadvantages: (1) the method is incapable of accurate measurements over a wide range of frequencies, and, (2) the calibration technique is lengthy and painstaking. These disadvantages are minimized by using a noncontact-type pickup, as is done in the instrument to be described.

Operating Principles

The Vibration Calibrator is a displacement measuring system which utilizes a noncontacting vibration pickup[3]. The vibrations are converted into electric signals by means of a mutual inductance transducer in the pickup (Fig. 1).

The mutual inductance between the two coils in the probe (and therefore the output voltage) is a function of the spacing between the probe face and the reference surface. If the reference surface is stationary with respect to the probe, the output is a d-c signal. By suitable arrangement of the two coils and the circuitry supplying them, the response curve (probe-to-sample separation versus probe output) can be made fairly linear throughout the operating range (Fig. 2). If the reference surface is vibrating, the output contains an a-c component proportional to the amplitude of vibration. This component is measured in a peak-to peak vacuum-tube voltmeter, as shown in Fig. 3.

Inasmuch as the transducer used has no moving parts of its own, it has a response that is flat to 20 kc with full-scale vibration ranges of 20 microinches to 20 mils. In addition, the unit is so designed that it may be calibrated against a measured static displacement at any time. As no surface contact is required for measurement, "loading" of the vibrating surface is not necessary. This feature is particularly useful in the testing of rotating shafts or of limited energy systems.

An input attenuator, having 10-db steps, provides peak-to-peak vibration ranges of 0.02, 0.06, 0.2, 0.6, 2, 6, and 20 mils full scale. The bandwidth of the system (limited by the VTVM) is flat to within less than 1 db from 10 cps to 20 kc, while a switch-selected choice of input time constants allows the elimination of hum or rumble vibrations (caused by motor laminations or passing vehicles, for instance) when it is desired to study the high-frequency components of vibration.

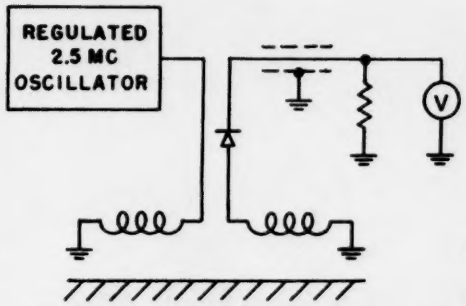


Fig. 1. Basic circuit for displacement measurements using the mutual inductance principle.

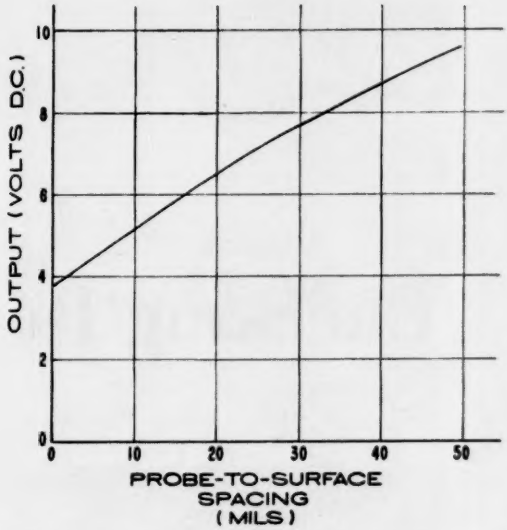


Fig. 2. Response curve.

Calibration

The calibration circuit used in the instrument is shown in Fig. 4. With the chopper operating and the reference surface at approximately 30 mils (0.03″) from the probe (as indicated by the probe d-c output), the potentiometer is adjusted for a zero (null) reading on the meter and then locked. This serves to establish a reference voltage equal to the probe output voltage at the existing displacement between probe and reference surface. The probe is then moved 20 mils (0.02″) toward the reference surface as indicated by a dial gage. The input to the VTVM under these conditions is a square wave with a peak-to-peak amplitude corresponding to a 20-mil displacement of the reference surface with respect to the probe. The sensitivity of the VTVM is adjusted to give a full scale reading on the 20-mil range of the meter. For operation (direct reading of vibration amplitude) the probe is displaced to the center of the range over which calibration took place and the chopper is switched out.

Applications

A function switch, used to select the operating mode of the instrument, permits use of the various circuits mentioned. Besides allowing direct meter readings of vibration displacement, the instrument is provided with voltage terminals permitting observation of the vibration waveform with an oscilloscope.

The Calibrator is a versatile electronic micrometer, and can be used to make displacement measurements of either stationary or vibrating surfaces. In its primary application as a vibration-pickup calibrating device, the pickup to be calibrated is mounted on a shaker table or other vibrating surface and the calibrator probe is mounted so that the probe uses the pickup case as a reference surface. Readings obtained from the vibration calibrator can be compared directly with those obtained from the pickup being calibrated.

The instrument can be used directly to measure vibration amplitude where a suitable support for the probe is available and where the vibrating surface is a metallic non-magnetic material such as copper, aluminum, or brass. Where the vibrating surface is either magnetic or nonconducting, the Vibration Calibrator still can be used by attaching to the surface a disc of copper or aluminum an inch or so in diameter and at least 0.01″ in thickness.

The Calibrator can be used in connection with rotating shafts to indicate run-out, eccentricity, shaft displacement, etc. The degree of accuracy obtained in this application depends to a large degree on the geometric configuration, with maximum accuracy being achieved when the shaft diameter is somewhat larger than the diameter of the probe face.

Secondary applications of the instrument include its use as a noncontacting micrometer in static applications, as well as use of the probe in metal-sorting operations and nondestructive tests.

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3. Yates and Davidson, "Wide Range Calibrator for Vibration Pickups," *Electronics*, September, 1953, pp. 183-185.
4. Kaufman and Mitchell, "Microscope Technique for Accelerometer Calibration," *Instruments & Automation*, Sept., 1955, Vol. 28, pp. 1510-1512.

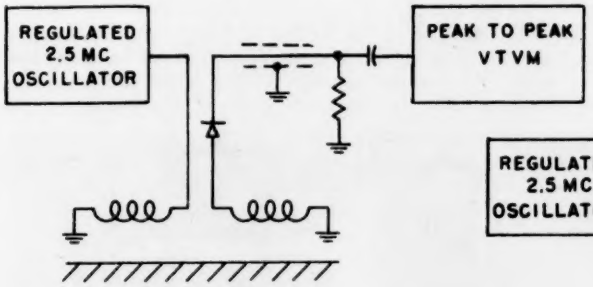


Fig. 3. Operating circuit.

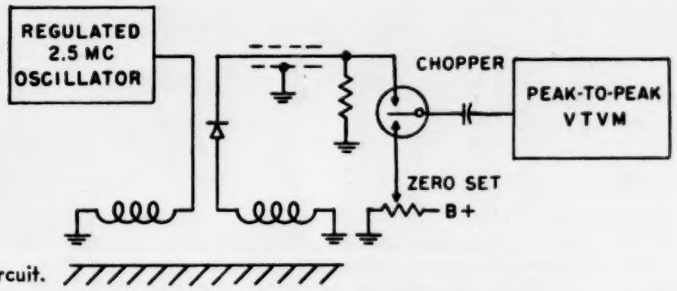


Fig. 4. Calibration circuit.

Checking Resistors in Production

Fig. 1. Production line of modern air-conditioned plant of Resistance Products Co.

Resistor manufacturers produce to varying tolerances. Here is how one manufacturer meets various finished-product tolerances and production-sequence tolerances from ±1% to ±0.02%.

EMIL REISMAN
Resistance Products Co.

EXPANDING high-quality resistor market is demanding closer tolerances. To meet narrowing tolerance requirements, manufacturers must establish suitable production-line standards for resistance checks that approach laboratory accuracy. Laboratory-type manual-balance resistance bridges are finding increasing use for such measurements.

Resistance Products Co. does its production testing with more than 90 Wheatstone-bridge instruments of three different types (Fig. 1). Their resistance checking procedures are typical of methods generally applicable for production of quality resistors.

Accuracy

Allowable resistance tolerances range from ± 1% to ± 0.02% for finished resistors (Fig. 2) used in digital and analog computers, guided missiles, radiation equipment and industrial and scientific instruments. Obtaining desired accuracy requires a succession of wire-trimming operations. Each trimming operation demands an increasingly accurate resistance measurement. A basic Wheatstone-bridge circuit (Fig. 3) is successively refined in design to meet the higher accuracy requirements.

Bridge Operation

In the basic circuit the resistor forms one leg of the bridge circuit. The ratio arms establish the instrument range; the rheostat arm permits manual balance of the bridge as indicated by a light-and-scale galvanometer (Fig. 3).

In production testing, the operator connects the resistor to be checked to the bridge terminals and adjusts the rheostat arm until the galvanometer shows an exact balance. The resultant bridge reading gives the resistance value within the accuracy limit of the bridge. (Test

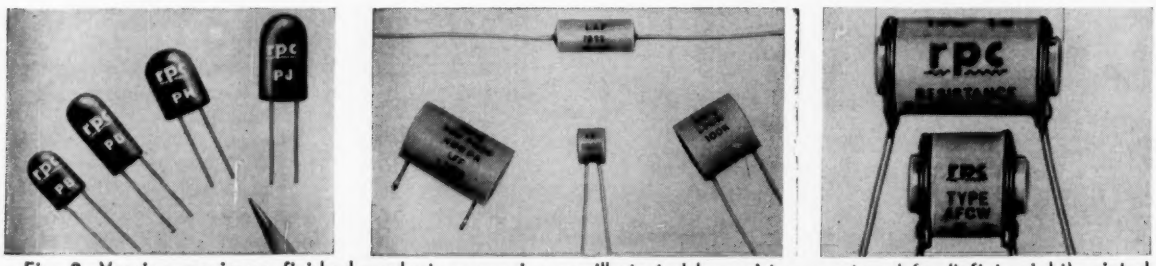


Fig. 2. Varying maximum finished-product accuracies are illustrated by resistors produced for (left to right) printed circuits (±0.05%), high altitude, salt water and shock (±0.02%), and general purpose (±0.02%).

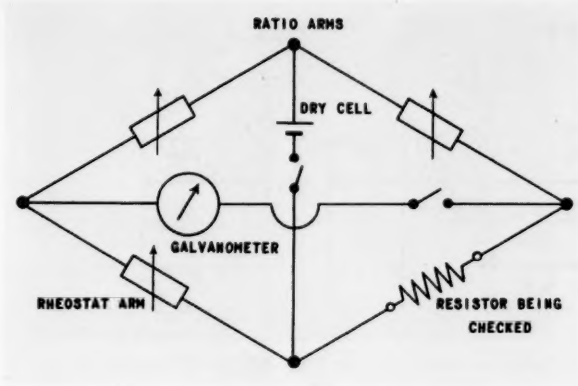


Fig. 3. Basic Wheatstone-bridge circuit is employed in all instruments used for checking resistance values.

bridges retain initial accuracies with no attention except routine maintenance. Some have been in three-shift service for as long as nine years.)

Production Sequence

First the Manganin, Evanohm, Karma or other resistance wire material is sampled and checked for resistance (in ohms) per foot. This work is assigned to a Wheatstone bridge (Leeds & Northrup 4760) with enclosed dial switches, featuring a bridge accuracy of ± 0.15%.

Resistor production begins with winding, or "laying-in" the wire on bobbins. The operator attaches the lead end of the wire to the bobbin lug, sets the winding machine for the predetermined number of turns, and then allows the winder to automatically lay on the fixed number of turns.

As shown in Fig. 4, the operator then uses the resistance bridge (L&N 4760) to trim the resistance down to a value close to its final rating. Ratio-arm resistors are set by one dial switch which provides seven values in ten-fold increments from 0.001 through 1000. The rheostat-arm range of 0 to 9999 is provided by means of four decade switches. Bridge accuracy of ± 0.15% is sufficient for this operation and for raw-material sampling.

The resistor is then annealed to relieve strains set up during winding. This stabilizes the resistance value, precluding changes that would otherwise occur over a period of time.

After annealing, the resistor normally is trimmed to its final value by use of a precision open-switch bridge (Fig. 5). This bridge (L&N 4725) uses plug-and-block switches in the ratio arms, and precise bridge resistors, to increase accuracy to ± 0.075%. The switch setting combinations permit a wide range of resistance checks.

Anthony-Pattern (L&N 4230) bridges are used for maximum accuracy in checking high-quality resistors (Fig. 6). These have a manufacturer's certificate for accuracy and are capable of accuracies greater than ± 0.015% when correction data are applied. Large plug-and block switches minimize contact resistance to achieve this accuracy. Individual resistors can be checked against a primary standard to insure the ultimate in accuracy.

The plant laboratory also uses an Anthony-Pattern bridge with an indicating amplifier (L&N 9835-B) as a null indicator. The extreme sensitivity of this indicator allows resistance readings to five significant figures for resistors up to 10 megohms.

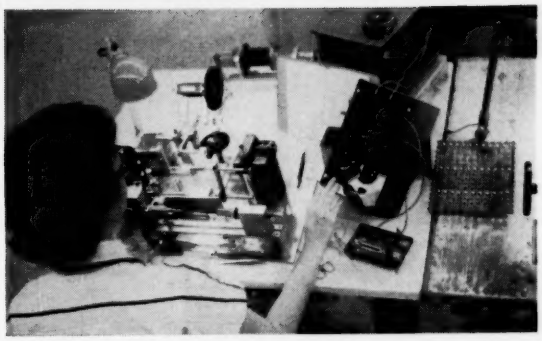


Fig. 4. After winding (at left), resistors are trimmed to their approximate final value with Wheatstone bridge (L&N 4760) with bridge accuracy of ±0.15%.

Fig. 5. Final adjustment of most resistors is made by operators using Wheatstone bridge (L&N 4725) whose accuracy is increased to ±0.075% by use of more precise bridge resistor networks, and plug-and-block and open-dial switches which reduce contact resistance.

Fig. 6. Still more accurate resistors are adjusted with this precise Anthony-Pattern bridge (L&N 4230). Accuracy is increased to ±0.015% by use of extremely precise bridge resistors and large plug-and-block switches which minimize contact resistance.

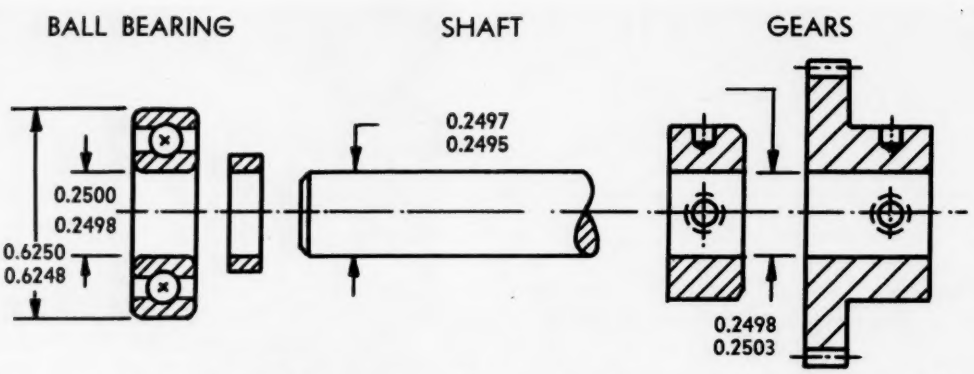


Fig. 1. Standard sizes for shafts and gears are based upon established standard sizes for ball bearings

Standardized Components

Standardization, a major factor in automation, is a valuable time and money saver in the area of precision engineered parts and associated components.

WINFRED M. BERG
PIC Design Corporation

STANDARDS established in the fields of hardware are *AN Standards*; those in electronic parts, *JAN Standards*. Drafting procedures have been simplified and standardized recently. Standards enable manufacturers to place orders anywhere, assured that assembly lines and drafting boards will not be confused by a mass of improper parts.

A.G.M.A. Fine Pitch Standards

The American Gear Manufacturers Association has established standards for gear manufacturing and checking. These are helpful in establishing uniform checking procedures and better manufacturer-customer relations.

Fine-pitch series gears are classified in four commercial and three precision tolerance categories, as shown in Tables 1 and 2. Note that A.G.M.A. Precision-3 gears are established through selection and segregation.

Table 1—Commercial Tolerances

Class	Total Composite Error (Inches)	Composite Tooth-to-Tooth Error (Inches)
Commercial 1	± 0.006	± 0.002
Commercial 2	± 0.004	± 0.0015
Commercial 3	± 0.002	± 0.001
Commercial 4	± 0.0015	± 0.0007

Table 2—Precision Tolerances

Class	Total Composite Error (Inches)	Tooth-to-Tooth Composite Error (Inches)
Precision 1	± 0.001	± 0.0004
Precision 2	± 0.0005	± 0.0003
Precision 3*	± 0.00025	± 0.0002

*By selection and segregation

Bore and Shaft Fits

The biggest problem in standardization is establishing basic fits between gear bores, ball bearing bores, and shafts. The A.G.M.A. in no way attempts to establish these tolerances and fits. However, the A.B.E.C. (standard ball bearing manufacturers) tolerance on ball bearing bores is the real starting point for establishing these basic standards (Fig. 1).

The example shown in Fig. 1 starts with a ball bearing bore of 0.2500 nominal, plus 0.0000 minus 0.0002 tolerance. Next a fit is established between these standard-bore ball bearings and basic shafts. This fit must provide a minimum clearance and still allow a hand fit—not a press or interference fit. A press or interference fit is always impractical for production and will not allow bearing removal without marring the shaft or ruining the expensive ball bearing.

Minimum acceptable bearing bore is 0.2498 so a shaft size of 0.2497 will allow 0.0001 clearance in an extreme case. A manufacturer's tolerance of plus 0.0000 minus 0.0002 allows the range required for practical manufacture. (These tolerances are maintained by grinding.)

Because shaft size is 0.2497 maximum, gear bore is made 0.2498 minimum, with a plus 0.0005 minus 0.0000

Presented at Servomechanisms Clinic, Third International Automation Exposition, 1956.

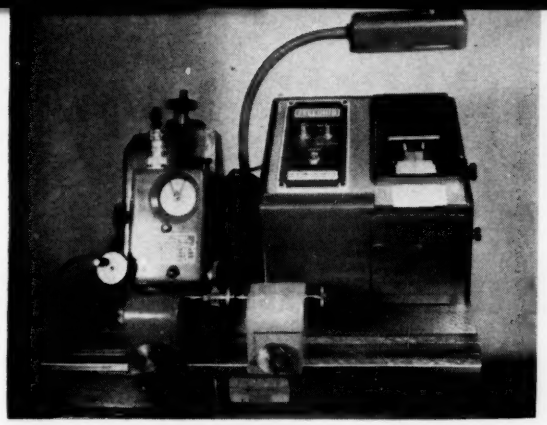


Fig. 2. Fellows Red Liner gear checker and recorder.

tolerance. Finer bore tolerances for A.G.M.A. Precision-2 gears are available through controlled manufacturing procedures and by selection.

Gear Cutting

The most common methods for precision gear cutting are (1) *hobbing*, as indicated by the Barber-Colman operation (Fig. 5) and (2) *gear shaping*, as indicated by the Fellows operation (Fig. 6).

A method for improving the quality of a shaped gear is gear shaving; performing a secondary operation as with the Fellows Gear Shaver.

Inspection

Pitch diameter, outside diameter, side wobble, tooth-to tooth error, and concentricity between bore and pitch diameter are very important factors for A.G.M.A. Precision 1, 2 or 3 gears. Proper inspection facilities must be available for quality control. Gear checkers available today are Fellows Red Liner (Fig. 2), Parkson, George Scherr (Fig. 3), and the Gleason Gear Checker (Fig. 4).

The Fellows and Gleason machines make a permanent record of each gear; Parkson and George Scherr provide a visual presentation. Because the first two are quite expensive, often beyond the means of small gear manufacturers, the latter two are used most frequently. A gear recorder accessory unit could be used with the Parkson or George Scherr type checkers.

In many instances, standardization makes possible better than Precision-1 tolerances at no extra cost. A wide variety of standard bore sizes are available, such as $\frac{1}{8}$" dia. for miniature precision application, 3/16" dia. for medium duty and $\frac{1}{4}$" dia. for heavy power and automation applications. Today, even A.G.M.A. Precision 1, 2 or 3 gears are available from stock; in the past only Commercial 1, 2, 3 & 4 were stock items. This enables engineers to prove out designs and schematics using stock parts in their original bread board.

For the convenience of those interested, a good bibliography of catalogs using new standards and simplified trends are as follows:

(1) PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y., Catalog 11 (free).

(2) Boston Gear Works, 14 Hayward St., Quincy 71, Mass., Catalog 55 (free).

(3) American Machine & Foundry Co., 261 Madison Ave., New York, N. Y., "Simplified Drafting" (free).

(4) National Standards Association, 616 Washington Loan & Trust Bldg., Washington 4, D. C., Air Force-Navy Aeronautical Standards, Complete set—6 loose-leaf books $205.00.

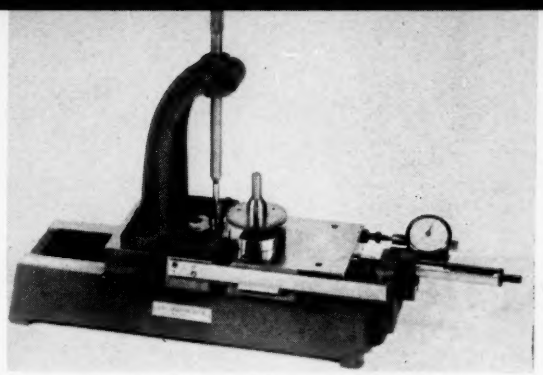


Fig. 3. George Scherr gear checker.

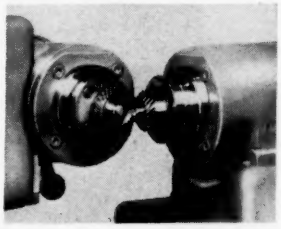


Fig. 4. Gleason gear checker.

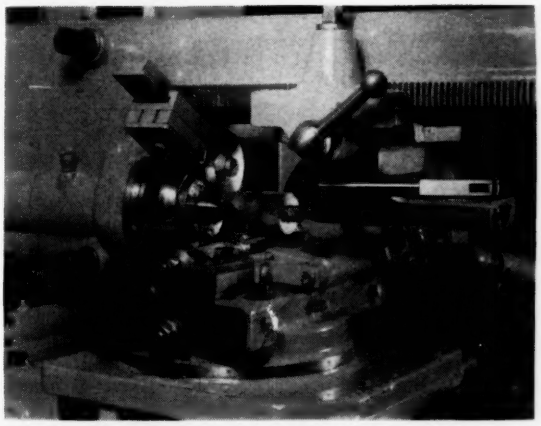
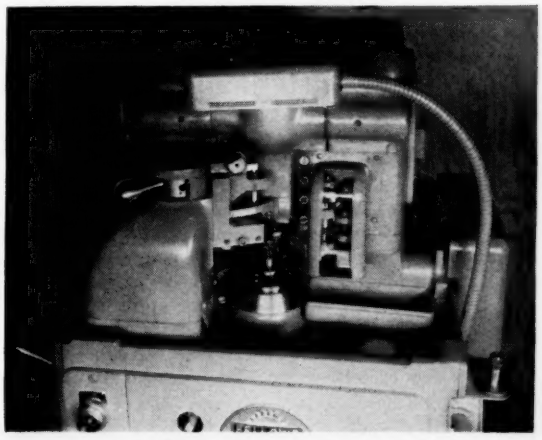


Fig. 5. Hobbing on a Barber-Colman solid-overarm machine with rotary burring attachment.

Fig. 6. Gear shaping.



The Cryotron--A Superconductive

Interest is growing in the cryotron, a superconductive element whose resistance can be switched from zero to a finite value by a small current in a control winding that is itself superconducting at all times. Here is an abstract of the original report on this interesting phenomenon.

SUPERCONDUCTIVITY was discovered in 1911 by H. Kammerlingh Onnes at Leiden, three years after he succeeded in liquifying helium. While extending electrical resistance measurements to this new low-temperature region he found that the resistance of mercury drops suddenly to zero at 4.12°K. Soon many other materials were shown to display this same unusual behavior. Niobium becomes a superconductor at 8°K, lead at 7.2°K, vanadium at 5.1°K, tantalum at 4.4°K, tin at 3.7°K, aluminum at 1.2°K, and titanium at 0.5°K. In addition to 21 elements, many alloys and compounds are superconductors with transition temperatures ranging between 0 and 17°K.

The resistivity of many superconductive materials is relatively high at room temperature, especially those which have high transition temperatures, such as niobium, lead, tantalum, etc. It is interesting that relatively poor conductors become superconductors at low temperatures whereas good conductors such as gold, silver, and copper do not. The resistivity of superconductive materials drops as they are cooled. Just above their superconductive transition, the resistivity is between 10^{-1} and 10^{-3} of their room-temperature resistivity, depending on the purity and mechanical strain in a particular sample.

Below the superconductive transition the resistivity is exactly zero. That it is truly zero is vividly demonstrated by an experiment now in progress by Professor S. C. Collins at M.I.T. wherein a lead ring has been carrying an induced current of several hundred amperes since March 16, 1954, without any observable change in the magnitude of the current.

Destruction of Superconductivity by a Magnetic Field

The foregoing discussion of the superconductive transition is valid only in zero magnetic field. With a magnetic field applied, the onset of superconductivity occurs at a lower temperature. If the intensity of the magnetic field is increased, the transition temperature is still lower. A plot of the transition temperature as a function of the applied magnetic field is more or less parabolic in shape, levelling out as absolute zero is approached. Such a plot for several common elements is given in Fig. 1.

If the temperature is held below the transition temperature for one of these materials, the resistance of that material is zero. Its resistance will remain zero as a magnetic field is applied until that magnetic field reaches a critical value. Above this value the normal resistance returns. If the field is lowered, the resistance disappears.

Raising and lowering the magnetic field thus controls the resistance of the material in the magnetic field by causing it to shift from its superconducting state to its normal state and back without changing the temperature. In Fig. 2, this operation corresponds to moving up and down on a vertical (constant-temperature) line which has its lower end in the superconducting region and its upper end in the normal region. If the operating line is moved

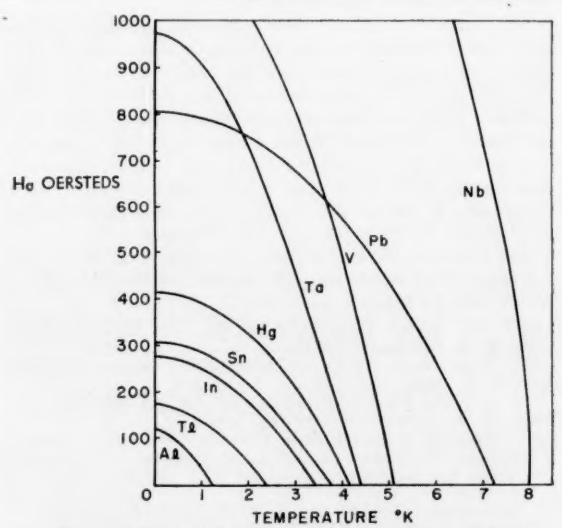


Fig. 1. Threshold magnetic field vs temperature for several common superconductors.

* Abstracted from an article of the same title, *Proceedings of the IRE*, April, 1956.

Computer Component

D. A. BUCK
Lincoln Lab, M.I.T.

to a lower temperature, the magnetic field required to reach the normal region is greater. For each of the materials which becomes superconducting, there is a temperature about 0.2°K below the zero-field transition which allows operation with rather small magnetic fields —between 50 and 100 oersteds. For lead, this temperature is about 7.0°K, for tantalum about 4.2°K, for tin about 3.5°K, for aluminum about 1.0°K. Tantalum has been used in many of the early experiments at M.I.T. because 4.2°K is the boiling point of helium at a pressure of 1 atmosphere and, therefore, the temperature of most storage tanks for liquid helium. Higher temperatures (up to 5.2°K) involve raising the pressure on the liquid helium bath; lower temperatures (down to about 1.0°K) involve lowering the pressure. At 4.2°K, then, experiments do not involve sealing of the lead-in wires.

In a typical cryotron, the resistance being controlled is in the form of a straight piece of wire about 1 inch in length. The magnetic control field is generated by current in a single-layer winding which is wound over the central wire (Fig. 3, top). The central wire is analogous to the plate circuit of a vacuum tube and the control winding is analogous to the control grid. In this case, the plate resistance is zero in the cutoff region and rises rapidly as grid-current cutoff is reached.

Superconducting Control Winding

The control winding is made of a superconducting wire which has a relatively high transition temperature. Niobium (formerly called columbium) is used because it has a very high transition temperature and can be drawn into fine wire which is strong. Lead or lead-plated wire is a second possible control-winding material.

At the temperature used, the control winding remains a superconductor at all times, and would remain so even in magnetic fields much higher than those being used to control the central wire. Therefore, there is no resistance in the control winding. A magnetic field, once established, needs no further energy for its support; the control current is maintained against zero back voltage. Similarly, all interconnecting wire is also superconducting.

Static Characteristics

The resistance of the central wire of a typical cryotron is plotted as a function of current in the control winding in Fig. 4. The central wire is called the gate circuit. This particular cryotron is made by winding a single layer of 0.003-inch insulated niobium wire over 0.009-inch bare tantalum wire. The insulation on the niobium is heavy Formvar. The finished winding has 250

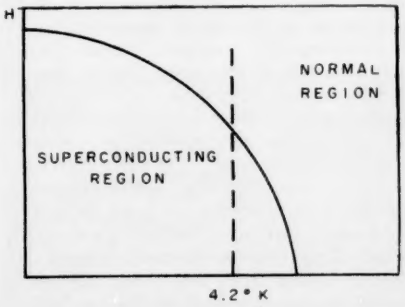


Fig. 2. Threshold magnetic field vs temperature for a superconductor. Dotted line represents an operating line.

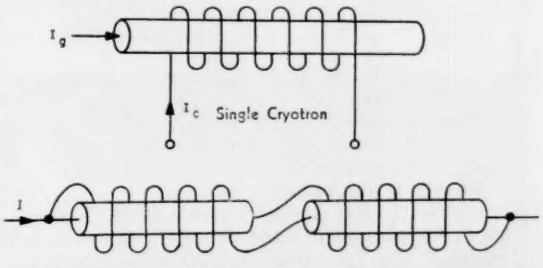


Fig. 3. Top, single cryotron; bottom, cryotron bistable element (flip-flop).

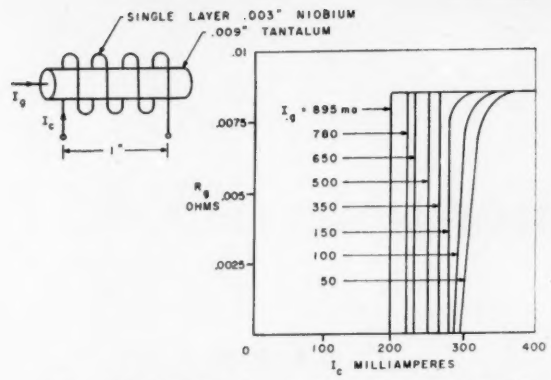


Fig. 4. Resistance of central wire (gate resistance) vs control current in the control winding (I_c) for various currents in the central wire (I_g).

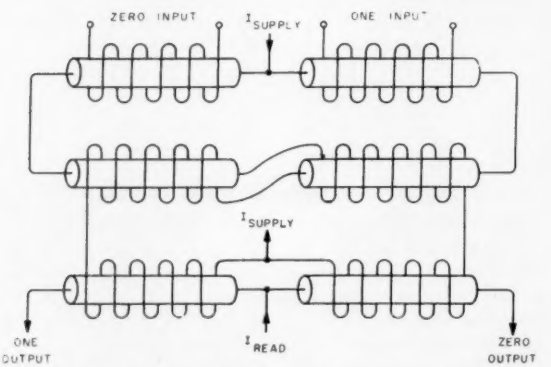


Fig. 5. Cryotron flip-flop with read-in cryotrons and read-out cryotrons.

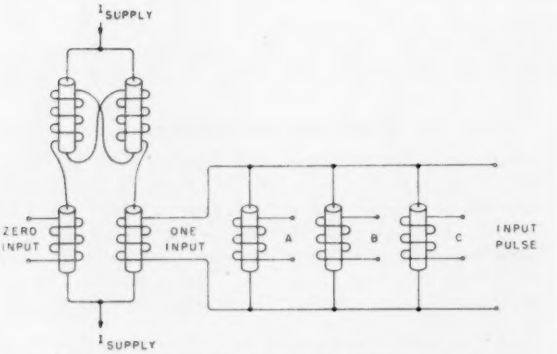


Fig. 6. Cryotron flip-flop with AND gates in one side.

turns per inch. In the midportion of the winding, the magnetic field due to a current is 124 oersteds per ampere. When the control current of Fig. 4 is translated into magnetic field intensity, the highest transition field is seen to be about 40 oersteds.

As current in the tantalum gate circuit is increased, the transition control current becomes lower. This effect is due to the additional magnetic field at the surface of the tantalum wire created by the gate current. This field, commonly called the self-field of the wire, limits the amount of current which can be carried by a superconductor.

The transition characteristics are very sharp for high gate currents. The additional sharpness is a peculiarity of the measuring technique wherein a current is passed through the gate circuit and the voltage across the gate circuit is measured. When resistance suddenly appears, I^2R loss in the gate circuit causes heating which lowers the critical field and speeds switching.

The magnetic field due to the control winding is along the axis of the central wire while the self-field of the wire due to its own control is tangential to the wire. The two fields thus add in quadrature and the resulting net field is the vector sum of two fields. Results indicate that the superconducting central wire reaches its critical field when the net field reaches a certain value, regardless of which way the net field points in relation to the center line of the wire. In one experiment, the curves of Fig. 4 were reproduced exactly for all four combinations of positive and negative control and gate current. There is no reason to suspect that there would be anistropy in the critical field for different orientations of the net field with respect to the wire axis as long as the control field is longitudinal, especially since the wire is polycrystalline. Thus the cryotron has an interesting property as a circuit element. Control is independent of the sign of the control current—it depends only on the magnitude. Furthermore, when the gate is ON, that is, in its superconducting state, current can flow in either direction, unlike a vacuum tube which can pass current only in one direction.

Cryotron Computer Circuitry

The low impedance level of cryotron circuitry dictates a high-impedance power supply (current source) with circuit elements connected in series. Each element allows the current a choice among two or more paths only one of which is superconducting; all of the current flows through the superconducting path. The current encounters zero back voltage except when the paths are changing. The standby power is therefore zero.

Fig. 5 shows a cryotron flip-flop with read-in cryotrons and read-out cryotrons. Fig. 6 shows a flip-flop with AND gates in one side.

Engineering A Cryotron System

The most unusual requirement of a cryotron system is that it operates at a temperature near absolute zero. Ten years ago this requirement would have precluded serious thought of such a system. Today, however, such an operating temperature is relatively easy to achieve. This change is mainly due to the work of Samuel C. Collins whose helium liquefiers revolutionized the field of low-temperature physics. Arthur D. Little, Inc., of Cambridge, Mass., has built seventy Collins helium liquefiers of a 4-liter-per-hour capacity. The liquefier at M.I.T. liquefies 27 liters per hour. Storage of liquid helium has also improved. Commercially available double Dewars which use liquid nitrogen in the outer Dewar lose less than 1% of their liquid helium per day.

A large scale digital computer can be made to occupy one cubic foot, exclusive of refrigeration and terminal equipment. The power required by such a machine extrapolates to about ½ watt, including refrigeration and terminal equipment. Operation in an inert helium atmosphere near absolute zero promises a high degree of reliability and very little thermal fluctuation noise. The device is somewhat faster than relays but far slower than vacuum tubes. A program is underway to increase the speed.

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R. P. LOWE

Proportioneers, Inc.

CONTINUOUS gravimetric proportioning may be defined as controlling the weight-rate of a continuous flow of multiple components to a process so that a constant proportionality is maintained.

Weight can be measured accurately because it depends on the force of gravity alone, and is not affected by either temperature or pressure. Volumetric measurements, however, must be corrected to a common standard of temperature (in the case of liquids) or temperature and pressure (in the case of gases). Dry materials are specified in terms of weight per cubic foot, but this value must be corrected for moisture content and particle size.

Initial considerations include: (1) physical state of the material, (2) whether the material to be proportioned is received in cylinders, gondola cars, or ships, (3) whether it is a product or by-product at the site, (4) whether storage and transfer facilities are adequate and reliable, (5) value per pound or per cubic foot of the components and end product, and (6) the tolerance of error within which the proportioning operation must be carried out.

Elements of the System

Gravimetric proportioning systems (Fig. 1) consist of four basic elements:

1. Load detecting and supporting means (suspended hopper or tank, weighing platform, conveyor belt).
2. Load reducing and transmitting devices (mechanical lever, pneumatic or hydraulic or electronic transmission).
3. Counterbalancing element (beam, hydraulic balance, pneumatic balance, or electronic null balance).
4. Control device (valve, gate, variable speed unit, or vibrating tray).

April Meeting: *Thursday, the 27th, Rio Hondo Country Club, Downey, Calif.*

Feature: *The Annual Hi Jinks.*

System Types

There are two types of proportioning systems—(1) constant rate or (2) flow responsive.

In a constant-rate system the feed rate of one component is maintained constant; in a flow-responsive system the weight rate may vary depending on demand requirements. Some operations require a minute by minute proportioning accuracy and slight variations in weight-rate are permissible.

Loss-In-Weight Proportioning Systems

Fig. 2 shows a Loss-In-Weight feeder in "package" form for simplicity and compactness.

In the upper part of the cabinet is the scale beam (4) with its lead screw (5) and traveling poise driven from a Telechron-motor-powered ratchet-and-pawl adjustable-speed unit (6). The outboard end of the counterbalancing beam carries a rubber wedge (8) which rides between the faces of a motor-driven oscillator (9) which determines the speed of rotation of the small Rotolock feeder (12) mounted at the lower end of the hopper. Should the hopper be losing weight faster than prescribed by the movement of the traveling counterpoise towards the fulcrum, a downward motion of the wedge results, reducing the speed of the Rotolock feeder. The same wedge and oscillator can be used also for vibrating a tray-type feeder.

This direct method of control is simple and rugged; the feeder will deliver within ½ of 1% of the rate for which it is set regardless of the amount of material in the hopper, varying humidity, type of chemical, or feeding characteristics.

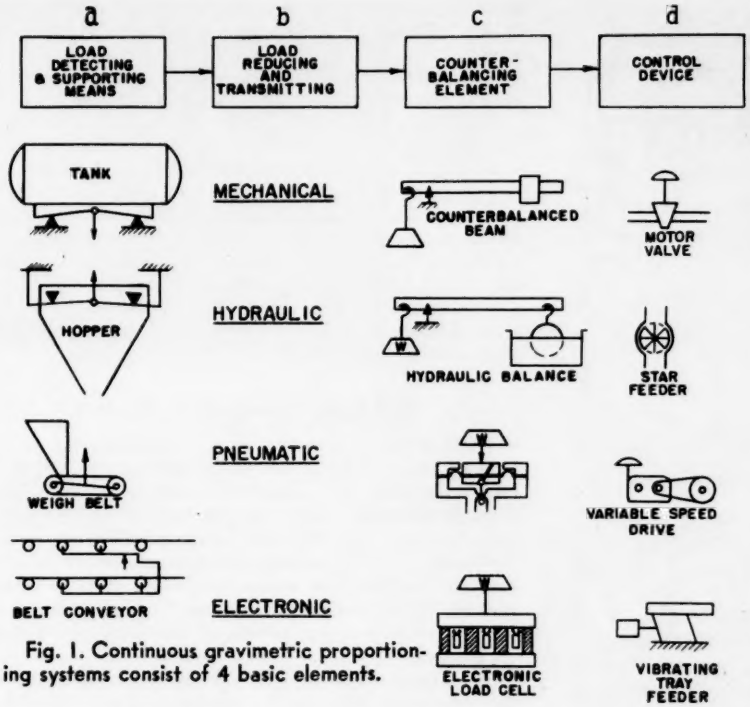


Fig. 1. Continuous gravimetric proportioning systems consist of 4 basic elements.

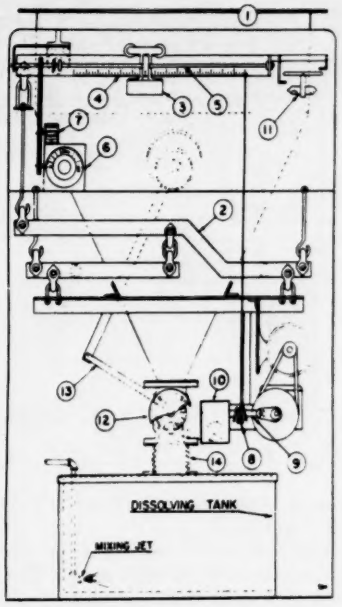


Fig. 2. Omega loss-in-weight gravimetric feeder with Rotolock feeding mechanism.

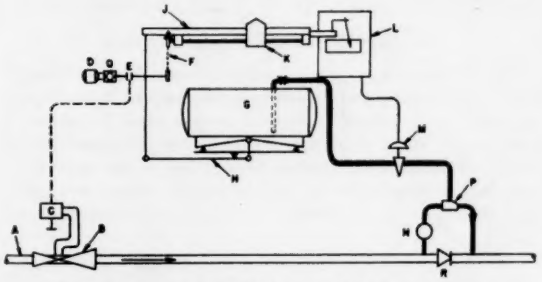


Fig. 3. Loss-in-weight tetraethyl-lead blender.

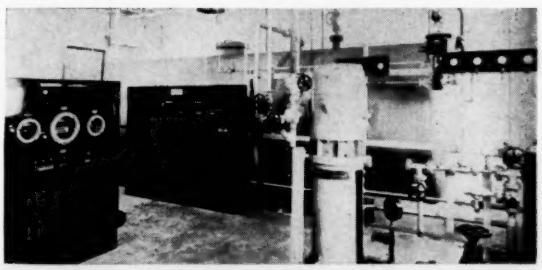


Fig. 4. Loss-in-weight automatic TEL scale and control panel installed at Canadian Oil refineries, Ltd., Sarnia, Ontario.

Proportioning TEL and Gasoline

Most base stocks start from storage tanks or hoppers, and the design of weighing system is determined by whether the process operation is to be batch or continuous. For example, in proportioning anti-knock compound to gasoline, the Lead Tetraethyl is received in tank-car lots. Owing to the toxic nature of this fluid the entire contents of the car is transferred to the tank on the proportioning scale at one time. This means that the weigh tank must be closed and vented, and that the operation of tank filling and fluid feeding must be carried on under vacuum.

Fig. 3 shows the system for gravimetric proportioning of TEL to gasoline. This is a *flow-responsive* operation because the leaded gasoline is usually going to transcontinental pipeline or tank and the gasoline rate is variable.

A Venturi tube (B) senses the flow of main-line (A) gasoline to be leaded. The differential thus produced is impressed upon a transmitter (C) of either the electronic or pneumatic type, which causes the receiver at the scale to retract the movable poise (K) on the scale beam at a rate (in pounds per minute) determined by the gasoline flow in gallons per minute. As the operation must be carried on under vacuum a slip stream of gasoline is passed through an eductor (P) which produces a vacuum to raise the TEL through the drop pipe in the tank. The rate at which the fluid leaves the tank is controlled by a diaphragm motor valve (M) with streamlined body to prevent build-up of lead deposits.

The control system (L) is of the null-balance type; the scale is in balance at all times. An increase in the flow of gasoline will draw the counterpoise towards the fulcrum more rapidly, causing the scale beam to tend to rise. The upset is picked up by the control instrument (L) which opens the TEL feed valve until equilibrium is restored.

This system delivers leaded gasoline with a finished product accuracy of ± 0.03 cc (by chemical analysis) TEL per gallon of gasoline with a dosage range of from 0.5 to 3 cc per gallon for motor fuel and 2 to 4.5 cc per gallon for aviation fuel. Gasoline flow rates are on the order of 2000 to 5000 gpm. All equipment must be explosion-proof.

Fig. 4 shows interior view of a TEL building; the

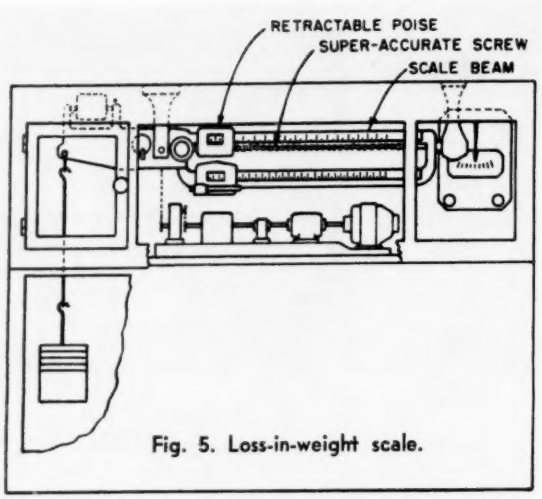


Fig. 5. Loss-in-weight scale.

control panel for the Loss-In-Weight Scale is in the left foreground, and the eductor pump is at the right.

Fig. 5 shows the essentials of a type of scale used for the continuous leading of gasoline. It is known as a Loss-In-Weight Scale, and its performance depends on the superaccurate screw which drives the retractible poise. In null-balance use scales of this type are accurate to 1 pound in 10,000 pounds; settings can be made in increments of 0.0075 cc.

Proportioning Multiple Liquids

Fig. 6 shows a group of synchronized Loss-In-Weight Scales controlling the continuous feeding of three liquids in preset proportions. The weight-rate of end product is controlled by a variable-speed-driven *Master Selsyn* motor. The poise retracting screw for each one of the Loss-In-Weight Scales is driven by a secondary selsyn under control of the master. Changes in formulation are made by adjusting an integrating type variable speed device between the slave selsyn and the poise retracting screw.

Accuracies of ± ¼% of weight-rate set for each component are obtainable with a system of this type.

Fig. 7 is a view taken in one of five plants equipped for this process. One of the three Loss-In-Weight Scales is seen with its vertical tanks behind it. The master control panel is at the right. The Loss-In-Weight Scale has been used also in an automatic pulp-sheet feeder—used by the rayon industry in the continuous steeping process (a step in the manufacture of alpha cellulose)—to control the weight of pulp sheets being delivered to a caustic in a continuous digester. It has been used also in pulp-sheet feeders installed in a large southern cellophane mill, and in many other similar applications.

Belt-Type Gravimetric Feeders

The belt-type gravimetric feeder is suitable for average feeding rates of from 500 to 20,000 pounds per hour. One type (Fig. 8) consists of a vibratory mechanism, a small materials supply hopper with a built-in shutoff gate, a short conveyor belt suspended from a scale mechanism, and a variable-speed transmission drive for the belt. Another type uses an electronic vibratory feeder instead of the mechanical vibrator. The machine can use a control gate positioned by the weight of material on the belt.

In general, material flows from the hopper through the adjustable gate to the vibrating feeder tray from which it is discharged onto the weigh belt. As a ⅛" vibrating movement of the tray will produce maximum feed, the feeder responds to minute fluctuation of the scale beam. Feed rate is changed by adjusting the variable speed transmission to drive the belt at the desired speed when carrying a pre-determined load per foot of belt. For example, if the belt is loaded with 20 pounds/foot, a belt travel of one foot per hour will deliver 20 pounds per hour; on the other hand, a travel of 100 feet per hour will deliver 2000 pounds per hour.

To prevent flooding of finely ground materials, an automatic solenoid-valve-controlled air cylinder is attached to the adjustable gate which is located just above the vibrating tray. The solenoid is energized through either of two mercury switches—one of these is tipped by a swinging baffle placed directly in front of the feeding tray so that it will operate immediately should the material start falling off the tray at too great

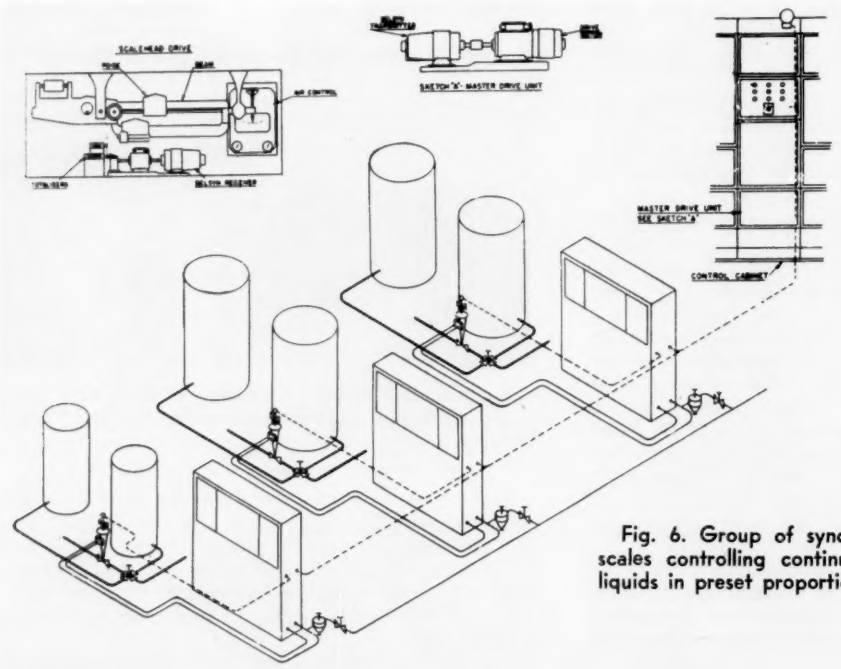


Fig. 6. Group of synchronized loss-in-weight scales controlling continuous feeding of three liquids in preset proportions.

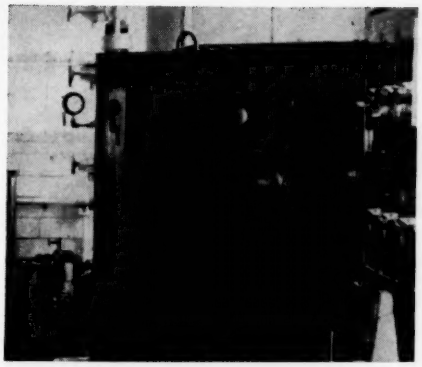


Fig. 7. Typical loss-in-weight scale installation for liquid feeding.

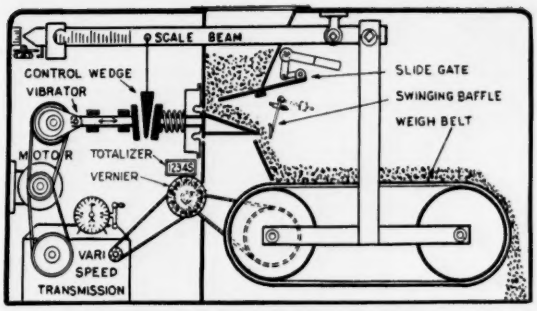


Fig. 8. Belt-type gravimetric feeder.

a rate. The other is operated by the scale beam when a serious overload on the belt causes it to tip up sharply. When the excess material has been delivered off the belt so that the balance is restored, the solenoid circuit through the switch is opened and the air cylinder automatically returns the gate to its open position.

Where extremely high rates of feed are required on materials which have a tendency to flood continually, a rotary feeding mechanism is used ahead of the vibrating tray.

The scales and control mechanisms are sensitive to 1/100 of a pound. Thus, if 20 pounds are being carried on the belt, the gravimetric error would be 20 divided by 100 or 0.2 pounds which represents an error of 1%. The average accuracy of a belt-type gravimetric feeder is plus or minus 2%, although spot checks may show a wider variation if flooding occurs.

Fig. 9 shows the application of belt-type gravimetric feeders in the continuous compounding of fertilizer mixtures. Five feeders deliver into a screw-type mixing conveyor. As all feeders are driven by synchronous motors there is no need for a common lineshaft. All feeders are handling the same weight per foot of belt and the variable speed units which determine feet of belt travel per unit of time are regulated remotely from the control panel for each feeder.

Fig. 10 shows a group of units in a feed mill. Note that each feeder is completely enclosed and that wiring is explosion-proof.

Pneumatic Load Cells

Fig. 11 shows another counterbalancing means, the *pneumatic load cell,* developed during the past ten years. A preformed diaphragm supports the load and positions an air pilot valve to support (pneumatically) the diaphragm in a fixed position for all values of load. In operation, a weight applied to the load cell platform, supported by the diaphragm, operates the air pilot valve to maintain the exact diaphragm pressure required to balance the weight. In this way, a direct reading of weight is obtained in terms of air pressure, which in turn can be translated directly into a control or integrating function. Other forms may have a stack of diaphragms with tare or pre-loading chambers and external or internal dash pot. Dash pots are usually filled with silicone grease or oil if external, or may be of the pneumatic type if internal.

Applications are found in dynamometer installations where vibration would soon reduce the sensitivity of scales employing knife edges; and also in conveyor scales where roller vibration, belt joints, and dust accumulations tend to reduce sensitivity.

The pneumatic signal from the load cell can be delivered to a pneumatic instrument-type controller which in turn controls a power cylinder. Such controllers obtain proportional control action by use of a flapper-nozzle unit, a booster relay, and suitable feedback. An integrating totalizer often is incorporated in the pneumatic control instrument.

The accuracy obtainable on a scale of this type is within $\pm$ ½ of 1% of *actual weight* passing over the scale from maximum to ½ of rated capacity; within $\pm$ 1% of actual weight from ½ to ¼% of rated capacity, and within $\pm$2% of actual weight from ¼ to 1/10th of rated capacity.

Electronic Load Cells

No discussion of continuous gravimetric proportioning systems would be complete without reference to the

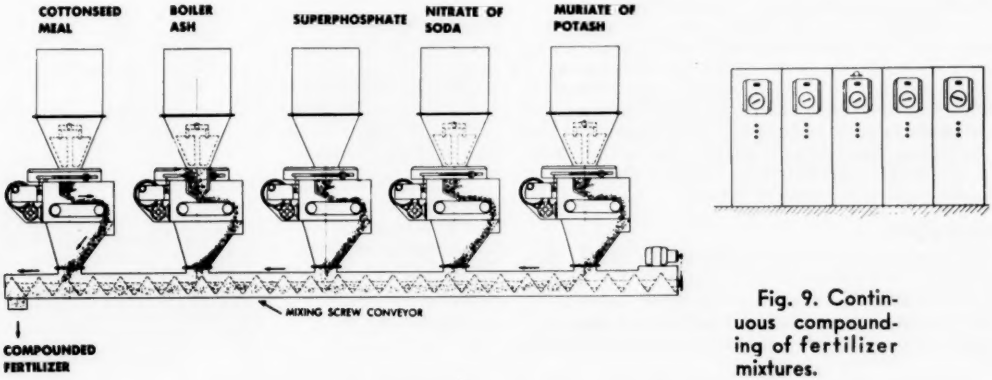


Fig. 9. Continuous compounding of fertilizer mixtures.

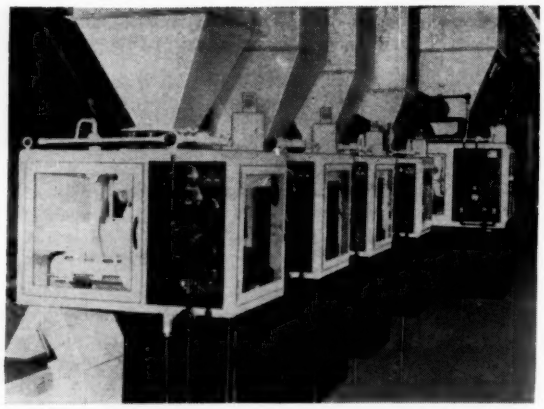


Fig. 10. Belt-type gravimetrics in a feed mill.

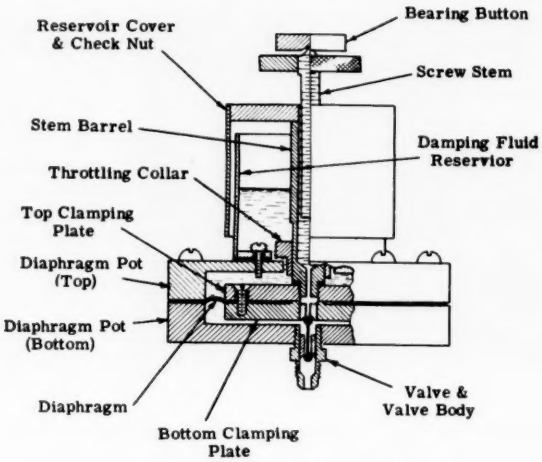
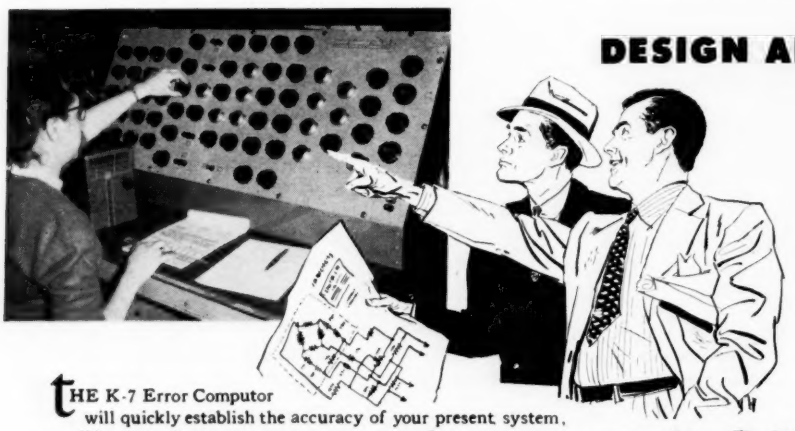


Fig. 11. Pneumatic load cell.

electronic load cell. The cell is manufactured either as a tension or compression element and consists of a high-strength steel column to the sides of which are bonded a wafer-thin matrix of bakelite-impregnated paper carrying fine wires. This *strain gage* is thus strained uniformly with the steel column, and the resultant change in resistance of the wire is translated in terms of weight. Whereas the strain gage has been widely applied to dynamometer load measurements, thrust measurements, static and dynamic weighing of forces and loads in connection with testing and stress analysis work, as well as batch weighing in the food and chemical processing fields, there are still some problems to be solved before it can be applied widely in the continuous weighing and proportioning field.

One of the problems to be overcome is that of zero drift, which in itself is not insuperable when frequent check calibrations can be made. Another problem is that in many outlying installations it is difficult to find operators capable of handling electronic equipment.

Although the more compact electronic equipment will in time find its place in the continuous weighing field, it must be remembered that the counterbalance scale with its lever multiplication system has met the test of time from as far back as the Pompeian civilization, and that the balance is still the standard in chemical analysis as well as in the Bureau of Weights and Measures.



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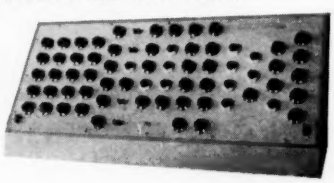

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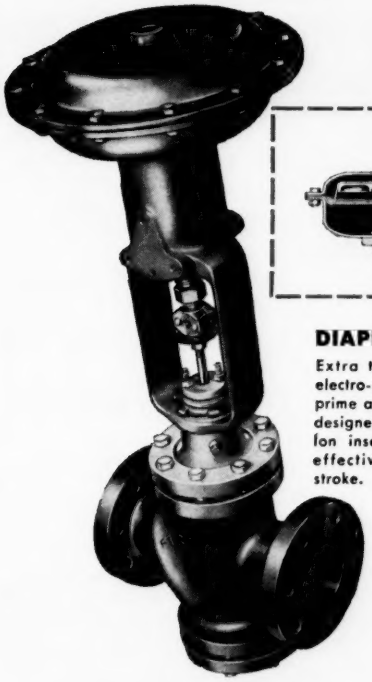

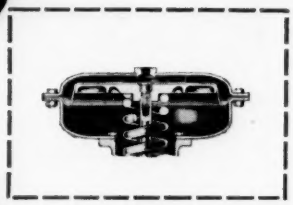

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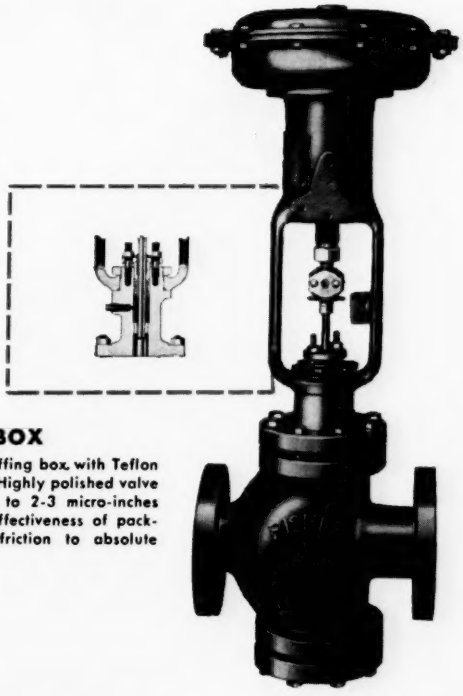

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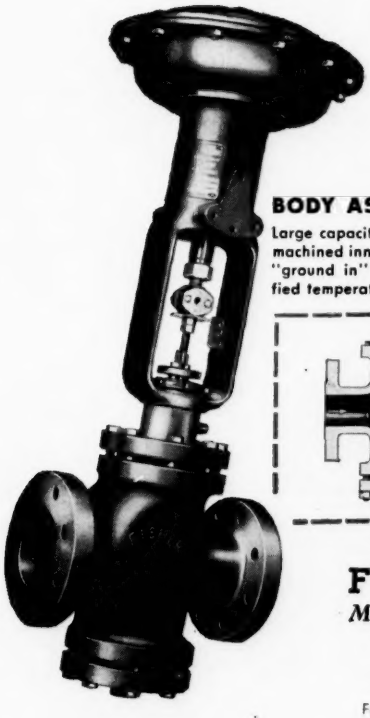

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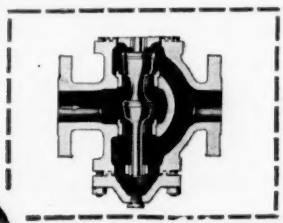

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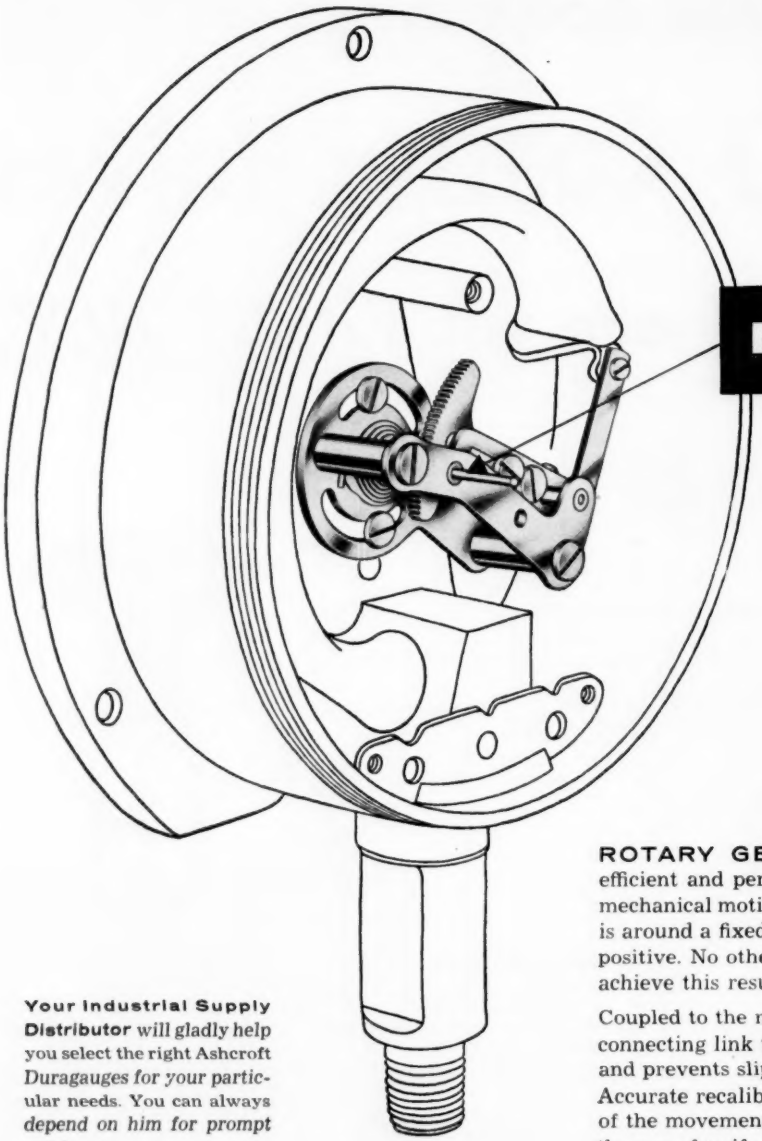

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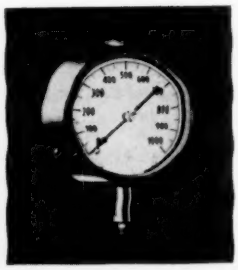

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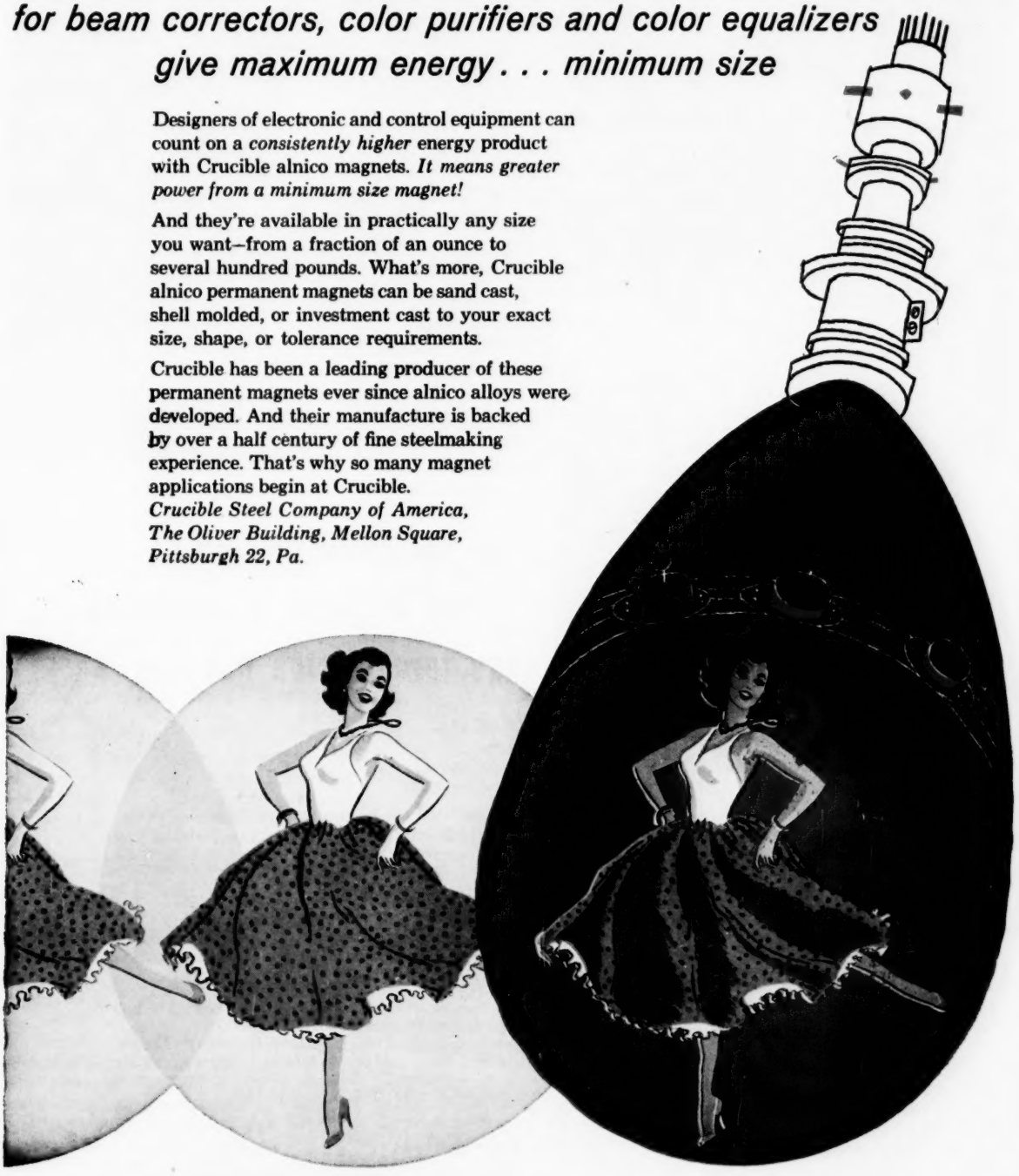

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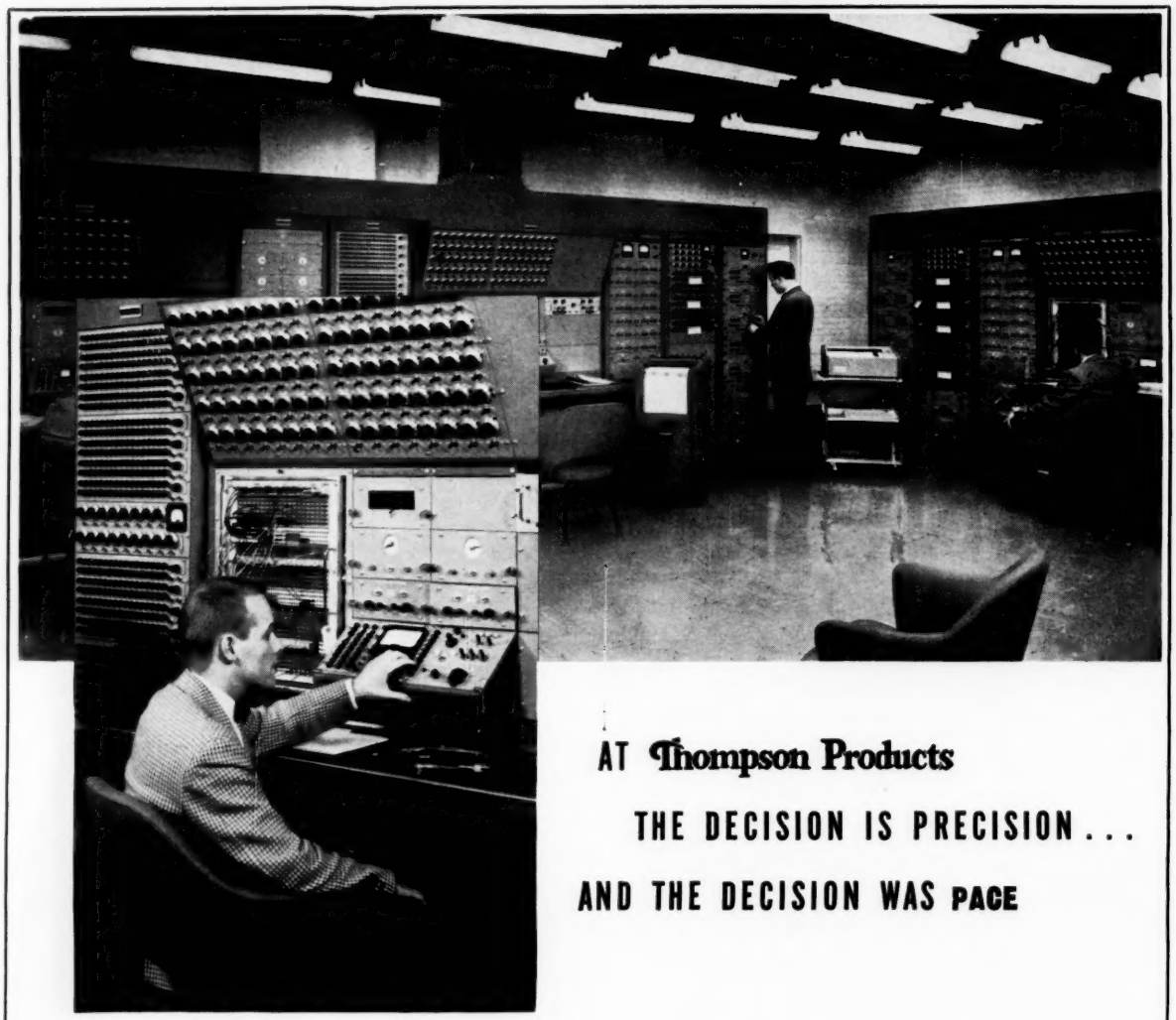

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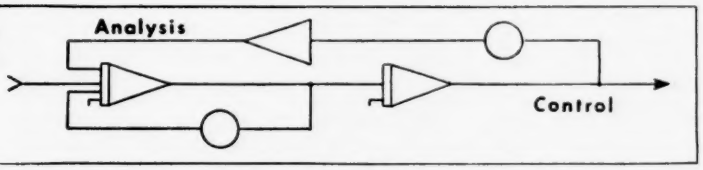
The SIMULATION COUNCIL Newsletter



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A. C. Robinson, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio; Chairman, Steering Committee.

Canadian Simulation Council
F. W. Pruden, National Research Council, Ottawa; Chairman, Steering Committee

Bits

Well, the First International Simulation Council Meeting in New York City is still supplying copy for the Newsletter. This month under Pieces we have a few introductory comments from representatives of the newer Councils (the Southeastern, Central, and Canadian), a discussion of what improvements are needed in simulation equipment, and Bernie Loveman's slightly edited notes on the Eastern Simulation Council participation in the ISC meeting.

Under "Information Without Theory" we have a bibliography on Simulation of Time Delays that Bernie sent us, and under Thots are interesting observations by a reader.

Thot (from a reader)

The Simulation Councils simulate councils. They have no constitutions, membership rolls, *nor dues;* in short, as to the physical trappings that usually signal a technical organization the Simulation Councils do not exist! Yet they stimulate interest, cross-pollinate ideas, process information, and otherwise produce answers applicable to real problems. The information thus generated is edited, published, and distributed to more than 20,000 readers of *Instruments and Automation* at a cost of not one red cent to the Councils. This is Simulation at its efficient best. Don't change it!

Pieces

INTERNATIONAL SIMULATION COUNCIL WELCOMES SOUTHEASTERN, CENTRAL, AND CANADIAN COUNCILS

Representatives of the three most recently organized Councils who were at the November meeting of the International Simulation Council in New York City felt that they were too new and too few to organize a technical discussion, so they were let off with a brief introduction on their Councils.

Dixon on the SES/C

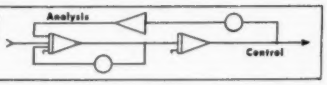
John McLeod, as Chairman of the International Steering Committee, introduced *Fred Dixon* (Georgia Institute of Technology, Atlanta) of the Southeastern group, oldest of the new Councils. Fred said that about a dozen organizations participate in their meetings: Arnold Engineering Development Center, Auburn Polytechnic Institute, Eglin Air Force Base, Georgia Institute of Technology, Lockheed Aircraft Corporation, Naval Mine Defense Laboratory, North Carolina State University, Oak Ridge National Laboratory, Patrick Air Force Base, Redstone Arsenal, Southern Research Institute, and the University of Florida.

The subject discussed is usually one of particular interest to the host. However, meetings at the Naval Mine Defense Lab (Panama City, Fla.) are of special interest because of good fishing in the vicinity.

McLeod mentioned the excellent Southeastern Simulation Council by-laws and suggested that if other Councils feel that they need by-laws, they should write them along similar lines. The by-laws sound impressive but allow members to do practically anything they like!

Cordes on the CS/C

Harry Cordes spoke for the Central Simulation Council, describing it as an embryonic organization. About 33



people came to their organizational meeting two months ago, which featured a tour of the Beech Aircraft Corporation (Witchita, Kansas). Oil companies, airplane manufacturers (Boeing, Beechcraft, Cessna, McDonnell), Midwest Research Institute, and Tinker Air Force Base were represented, and it was an encouraging turnout. Some of the groups are not yet active in the analog field.

Pruden on the Canadian S/C

Fred Pruden (National Research Council, Ottawa, Canada), speaking or the six-day-old Canadian Simulation Council, said that if the Central Simulation Council was embryonic, the Canadian one was just a gleam in somebody's eye! There were 20 groups represented at their organizational meeting, including two aircraft companies (Avro in Toronto and Canadair in Montreal), two government installations (Government Missile Establishment at Quebec and National Research Council in Ottawa), and a number of electrical and control people. There were 30 persons present, most of them enthusiastic.

As Function Generation seems to be a popular sport these days, Fred said, it would be the subject of their next meeting (held at Canadair on 8 February 3.*

What Next in Analog Computers?

Having introduced the newer Councils, McLeod turned the discussion to the subject of *Stan Rogers'* (Convair-San-Diego) paper of the previous day, "What Next In Analog Computers?". What, he asked, would users like to be able to do with their analog equipment which they cannot do now? He asked this question, he said, to focus attention on what the users need and want, with the idea that if there is any activity in the area we want to find out about it, and if there is not, we want to see some started.

The point in Stan's paper that had elicited most comment was the possibility of dumping the contents of a computer in such a way that at some later date the operator can easily restore the problem and be sure it is the same problem. *Mrs. Bauer* (Reeves Instrument Corp., New York, N. Y.) pointed out that this doesn't prove that you are solving the *right* problem in the first place. No one knew what to do about that!

W. G. McClintock (Rensselaer Polytechnic Institute, Troy, N. Y.) suggested using a mechanism near the computer to record changes as you make them.

Edward Massell (Electronic Associates, Long Branch, N. J.) suggested that instead of having to speak into a recorder, the changes be automatically printed out as made.

Suzette, trying to get speakers to give their names, suggested that what the Simulation Council needs is a recording machine that will look around the room and see who's speaking.*

Massell was asked if the EA information spill-out is in a form which can be readily re-injected. He explained that usually it only comes out in typing copy, but that it can be put out in punched tape, which can be fed back. That, however, is not as complete as Stan has suggested; it cannot do patching.

Alfred Gronner (American Machine & Foundry Co., Greenwich, Conn.) suggested photographing the patchboard.

Jim Stone (Battelle Memorial Institute, Columbus, Ohio) told about trying photography on a 21-amplifier computer; he found it extremely difficult to follow the wires.

Morris Rubinoff (Moore School, University of Pennsylvania, Philadelphia) pointed out a fundamental difference between voice recorded on tape vs. punched: If you punch information in tape, you can read it backwards.

A. C. Robinson (Wright Air Development Center, Wright-Patterson Air Force Base, Ohio) mentioned that digital people are now thinking in terms of programming in English. You type out "put so-and-so in so-in-so" and it does it. Wouldn't it be nice if we could do this with analogs; just tell the computer to connect amplifier so-and-so to amplifier so-and-so?

McLeod said he was for leaving the human out as much as possible. What would a computer make of his Southern accent?

Robby explained that he wasn't talking to it, he was typing to it.

Suzette wanted to know what the computer would make of some people's spelling.

Jules Lehmann (RCA, Princeton, N.J.) said that these techniques are based on using the digital computer itself for making translations, so you would have to put a digital computer side-by-side with the analog computer.

McLeod said this would be OK; it is what they are doing at Convair—but for different reasons.

Fred Dixon reminded us that there are three general areas involved in our discussion. There are problems associated with mere bigness, others with large numbers of runs, and there are problems which have to do with the limitations of individual components—the fact that components when hooked together in large numbers are liable to exhibit undesirable characteristics which they do not have individually. We should make it clear which area we are talking about.

The discussion turned to relays. "Do you expect a relay not to pull in when it is supposed to, or are you concerned with contact resistance?"

Cronner suggested the use of relays of the mercury type.

McLeod replied that they are more expensive and bigger.

Otis Updike (University of Virginia, Charlottesville, Va.) said that the telephone company has developed a dry-reed type of relay which is supposed to be excellent but will probably be expensive. But it is compact and available with a large number of contacts. The coil is not in individual tubes; instead a bank of the tubes is in a single coil. Progress is being made in reducing the cost by automating production.

Rubinoff suggested consideration of a cross-bar switch.

Gronner said he had investigated the reliability of cross-bar switches, and they come out about the same as individual relays.

Lehmann said that they have hooked up relays in a cross-bar method, but that it doesn't seem reasonable to use cross-bars as such. They used individual latching relays so that it would not be necessary to have the power on throughout the problem.

McLeod commented that the only reason which had been discussed for wanting to change the problem was multi-shift operation. However, in his experience they often wanted to change the problem because the engineer was using the computer empirically; any "back-to-the-drawing-board" results meant that they either had to tie up the computer while they

*The group at New York agreed that repetition of subjects is not necessarily bad. There have been several meetings on function generation, but others will be sure to bring out additional interesting material. Simulation and analog computation are making so much progress that one must review progress on a given subject every few months to just keep up.

*Equipment manufacturers: Please note!

bug-hunted, or they had to change the problem.

Robby observed that he considered being able to get the problem off and store it and get it on again correctly as the major advantage of the digital over the analog at the present time. Therefore improvement of the analog in this area would constitute the maximum improvement in the competitive position as things now stand.

Lehmann said most effort has been directed toward making computers easier to use, while little attention has been paid to components, which are much what they were four or five years ago.

Bernie Loveman (Reeves Instrument Corp., New York, N.Y.) didn't agree, saying he remembered a few years ago when if you talked about a 0.01% resistor you were way off. Now everyone talks about 0.01, 0.001, and he has seen a potentiometer divider which somebody claimed was 0.0001%! They are also improving capacitors. And certainly improvements have been made in multipliers.

Bernie mentioned the graph in Korn & Korn's old book in which they showed a plot of price vs. accuracy going up asymptotically. In the latest edition the axis has moved out at least one order of magnitude. "I think that indicates quite an improvement," Bernie said.

Lehmann said what he meant was; are they considering transistorizing amplifiers or looking into other solid-state components?

John Strong (Electronic Associates, Princeton, N.J.) explained that in recent years the emphasis has been on function generators and multipliers, and items which were far behind the operational amplifier's performance.

William Dittrich (Frankford Arsenal, Philadelphia, Penna.) observed that nothing has been done about the recording devices, which are much lower in accuracy than the rest of the computer.

McLeod stated that the limitation has been in the servos, but that electrostatic printing promises to break this bottleneck wide open by making it possible to record as fast as they can move the paper.

Otis Updike said he had a couple of long-range ideas, one of which was using high-speed wide-bandwidth equipment. There are approaches such as carrier amplifiers with transistors modulators and demodulators. Carrier frequencies in the tens of kilocycles have been exploited for special-purpose analog computers. Another area would be the use of modes of electrical signals other than DC voltages—possibly frequency—for covering extremely wide ranges of variables.

"Better liaison between the users as represented by the Simulation Council and those who build and use special-purpose analog equipment such as Flight Trainers might be very fruitful. The representatives of this second group might contribute some provocative ideas," he concluded.

EASTERN S/C MEETING AT TIAE

The two-year old Eastern Simulation Council held their twelfth bimonthly meeting as the fourth and last of the International Simulation Council meetings in New York last November. Their technical discussion was preceded by a meeting of 65 representatives (see picture) of 56 organizations at Project Cyclone, Reeves Instrument Corporation, on the morning of 29 November. Five study groups met during lunch.

Physical Simulation

Nine members (7 organizations) attended the Physical Simulation Study Group (*W. Wisnowski*, Chairman). Reasons for using physical simulation were discussed, including cases in which:

1. Mathematical representation is not available.
2. Physical simulation is simpler.
3. A check of equations representing the system is desired.

It was pointed out that physical simulation can lead to errors if the equipment used is atypical. Comprehensive bench testing is required to avoid this.

Operations Research

Twelve members (11 organizations) attended the Operations Research Study Group (*Howard Hamer*, Chairman). It was suggested that the proper role for simulation in operations research is the establishment of mathematical models. The use of analog techniques in queuing theory, production control, and the theory of games also was discussed.

Dead Time Simulation

Eleven members (10 organizations) attended the Dead Time Simulation Study Group (*Bernie Loveman*, Chairman). Bernie circulated a "Bibliography on Simulation of Time Delays" (see Information Without Theory). Several members "volunteered" to abstract these papers to increase the usefulness of the bibliography. The work is to be coordinated by the chairman.

Single-Amplifier Transfer Function

Ten members (10 organizations) attended the Single-Amplifier Transfer Function Study Group (*Hideo Mori*, Chairman), which discussed the MIT-DACL single-amplifier network for simulating time delays.

Definitions

Nine members (9 organizations) attended the Definitions of Funda-

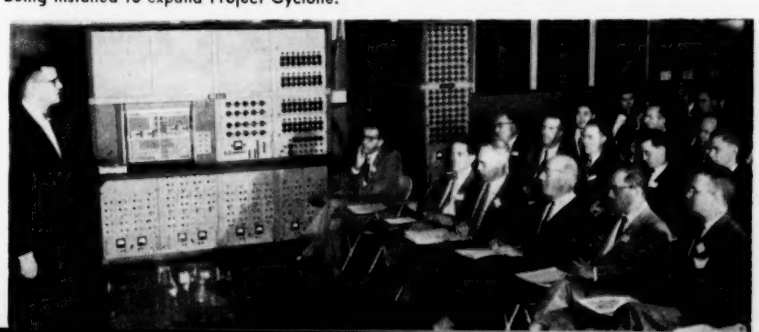
Dr. Louis Bauer, Director of Project Cyclone, welcomes members of the Eastern Simulation Council at its November session at Reeves' East 91st Street plant. Among those shown are:

First row, left-to-right: (1) Jules Lehman (RCA Laboratories, Treasurer E.S.C. 1956), (2) Alfred Gronner (American Machine & Foundry Co.), (3) W. Frank Richmond, Jr. (G. L. Martin Co., Chairman E.S.C. 1956), (4) Bernard Loveman (Project Cyclone, Reeves, Secretary E.S.C. 1956, Vice-Chairman E.S.C. 1957), (5) Howard Hamer (Electronic Associates, Inc.).

Dr. Harold S. Skramstad (National Bureau of Standards, Chairman, E.S.C. 1955) is the second man in the second row, sitting next to H. Elmore Blanton (Hycon Eastern Inc.).

H. Mori (M.I.T., DACL, Secretary E.S.C. 1957) is end man in the third row.

In the background may be seen part of the new Series 400 REAC® computers which are being installed to expand Project Cyclone.



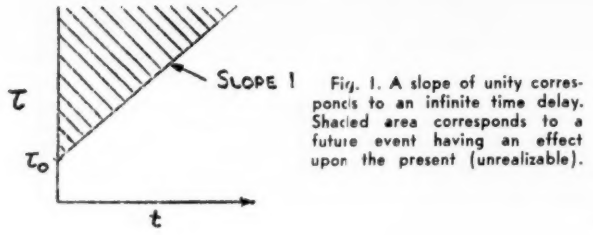


Fig. 1. A slope of unity corresponds to an infinite time delay. Shaded area corresponds to a future event having an effect upon the present (unrealizable).

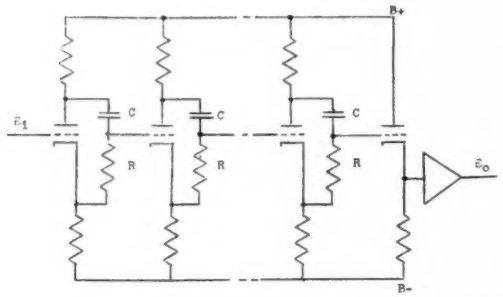


Fig. 2. Electronic time-delay circuit developed at Project Cyclone. The transfer function for N stages is $(1-\tau s)^N/(1+\tau s)^N$, where $\tau=RC$.

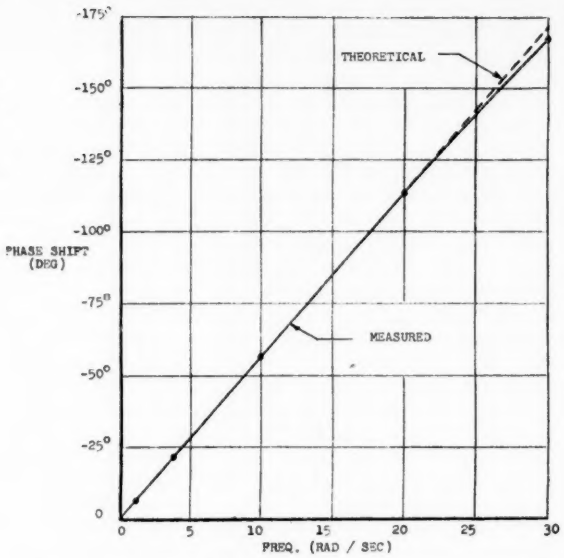


Fig. 3. Performance (phase shift) of circuit in Fig. 2 for eight stages, with R=1 megohm and C=0.005 microfarad.

mentals of Simulation Study Group (*Morris Rubinoff*, Chairman). Morris presented his definition: "Simulation is the representation of the salient features of a process or device for reasons of economy of people, or time, or money, etc., and/or for convenience." The group discussed this definition at some length. It was suggested that simulation could be divided into three phases:

(1) Representation by mathematical equations, models, or physical analogy.

(2) Utilization of computing mechanisms, devices, or systems.

(3) Determination of responses which are subsequently related directly to the (anticipated) performance of the process or device under study.

There was some difference of opinion as to where simulation ends and testing begins. Discussion of mathematical foundations of simulation was left for the future.

Bauer on "Simulation of Time Delays"

At the technical session in the New York Trade Show Building that afternoon *Dr. Louis Bauer* (Project Cyclone, Reeves Instrument Corp.) introduced the subject "Simulation of Time Delays" by presenting two definitions of time delay, the first in the frequency domain and the second in the time domain. The former is the transfer-function relationship exp $(-\tau s)$; the amplitude is unity and independent of frequency, while the phase shift increases linearly with frequency, i.e., $\tau\omega$. The latter definition is of course $f(t-\tau)$. In this case, the performance of the simulator may be evaluated by determining the r.m.s. error with a specified (e.g. step or velocity) input.

Next the terms "adjustable" and "variable" time delays were described. For the former, τ is a parameter that has a specified value which can be adjusted for each run. The time delay is variable if τ is a function of one of the problem variables or is a programmed function of time. The transfer-function definition for time delay does not apply to a variable time delay (nonlinear relations do not have transfer functions). On the other hand, $f(t-\tau)$ applies at all times. If τ is expressed as a function of time, Figure 1 shows the region for realizable values.

In closing, Louis listed the following basic methods available for simulating time delays:

(1) Approximating the transfer function
   a. Using dc amplifiers
   b. Using special RC circuits
(2) Storage and readout
   a. Sampling the charge on capacitors, or other discrete stored values.
   b. Tape recorder

A bibliography on "Simulation of Time Delays" was distributed (see Information Without Theory).

Time Delay Circuits at Cyclone

Bernie Loveman described two time-delay circuits constructed at Project Cyclone. The first (Figure 2) is an inexpensive electronic means for approximating the transfer function, exp$(-\tau s)$. Each stage is a phase inverter. The signals at the plate and cathode are equal in magnitude and 180° out of phase. The attenuation of each stage is about 0.9. A cathode follower is used to unload the last stage. Figure 3 shows performance (phase shift) for eight stages with R = 1 megohm and C = 0.005 microfarad.

Figure 4 is a block diagram of an Electromechanical Time Delay. The input signal is sampled by switch D and successive sampled values are stored on the 1-mfd capacitors. These voltages are picked up at some later time on switch A, B or C and used to feed the continuous interpolating potentiometer. Note that switching takes place at points A, B and C when the potentiometer arm is respectively in sectors BC, AC, and AB. In this way a smooth interpolated output (no step discontinuities) results. The position servo is used to produce a variable time delay. The rate servo is used to control the sampling rate and also affects the delay time.

Mori on DACL Delay Circuit

Hideo Mori (Massachusetts Institute of Technology, Cambridge, Mass.) described a circuit (Figure 5) constructed at the Dynamic Analysis and Control Lab of MIT for approximating a time delay:

$$e^{-\tau s} = [(1-\tau s)/(1+\tau s)]^8$$

Note that since capacitor coupling

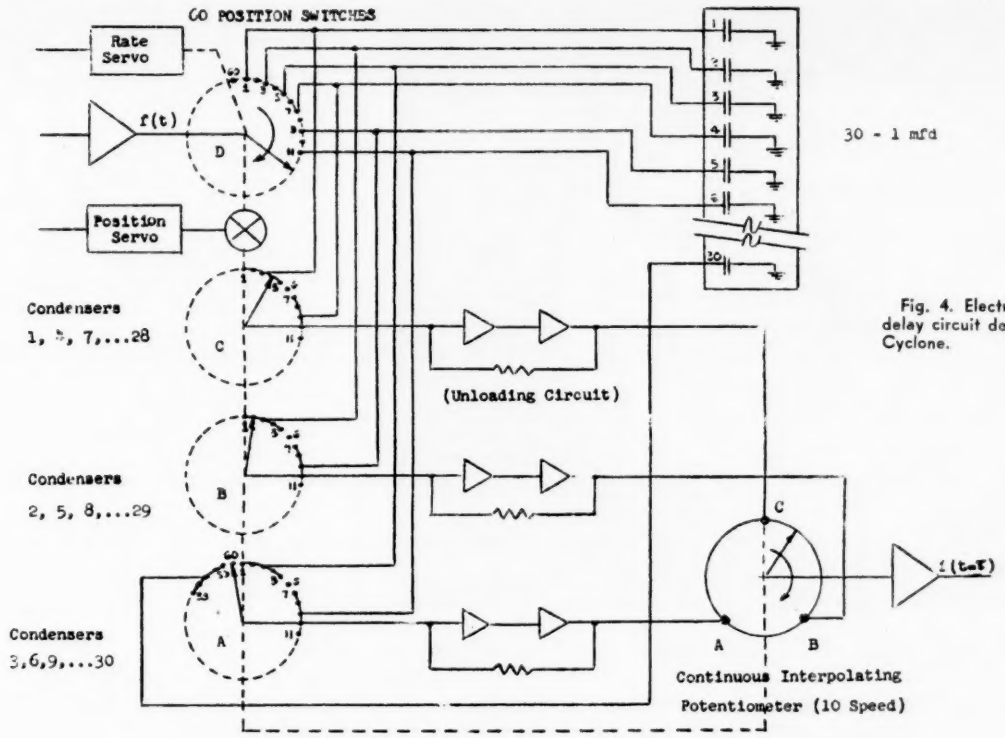


Fig. 4. Electromechanical time-delay circuit developed at Project Cyclone.

is used between stages, the dc amplifiers 2 to 5 do not have to be chopper-stabilized. The exponent 8 can be increased by additional stages.

When writing out the expression for the actual transfer function of this chain of amplifiers, there results a rather formidable expression consisting of a sum of N products. This sum is used to approximate the series resulting from expanding

$$[(1 - \tau s)/(1 + \tau s)]^{2N}$$

The constant factors multiplying C and R depend upon N.

Johnson on Delay Circuits

The next speaker was *S. O. Johnson* (Westinghouse, Atomic Power Division, Pittsburgh, Penna.) who described time delay circuits in which the approximation for exp $(-\tau s)$ is a ratio of quadratics or products of such ratios, i.e.,

$$\frac{(\tau^2 s^2 - 2\xi\tau s + 1)}{(\tau^2 s^2 + 2\xi\tau s + 1)}$$

A single section with zeta equal to 0.866 is useful for as much as 2 radians phase shift. For two cascaded sections with optimum zeta and tau, the maximum useful phase shift is 7.5 radians with an error less than 0.021 radian. For four sections the maximum phase shift is 13.5 radians and the error is less than 0.01 radian. A circuit for a single quadratic ratio is shown in Figure 6.

Special circuits had to be devised to approximate variable time delays with quadratic ratios. If the resistors, r and R, are replaced with potentiometers (maximum available resistance 500K) then for useful delay times the capacitor sizes are excessive. To overcome this difficulty the circuit shown in Figure 7 was devised. Now six amplifiers and two products are required for each quadratic section. In the second circuit (Figure 8), the number of amplifiers has been reduced to four, but three products are required. A disadvantage of these circuits is that the passive components are critical. The range of delays obtained was from one to 10 seconds.

These circuits are based on those developed in reference 16 of the bibliography under Info.

McClintock on a Tape Recorder

The final speaker, *Walter McClintock* (Rensselaer Polytechnic Institute, Troy, N.Y.), described a tape recorder developed at RPI for use with REAC equipment. Features of

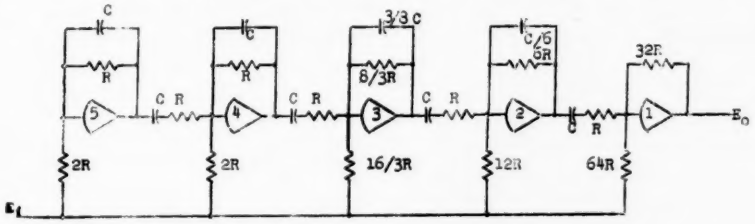
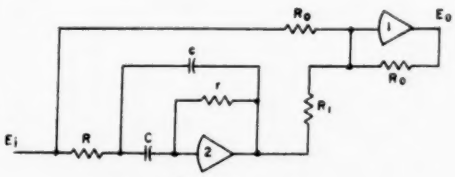


Fig. 5. DACL delay circuit.



$$\frac{E_o}{E_i} = \frac{\tau^2 S^2 - 2\zeta\tau s + 1}{\tau^2 S^2 + 2\zeta\tau s + 1}$$

Fig. 6. Circuit for a single quadratic ratio, with transfer function.

WHERE $\tau = \sqrt{RrCc}$ $\quad \zeta = \frac{1}{2}\left[\sqrt{\frac{C}{c}} + \sqrt{\frac{c}{C}}\right]\sqrt{\frac{R}{r}}$ $\quad R_1 = \frac{R_o}{4\zeta^2}$

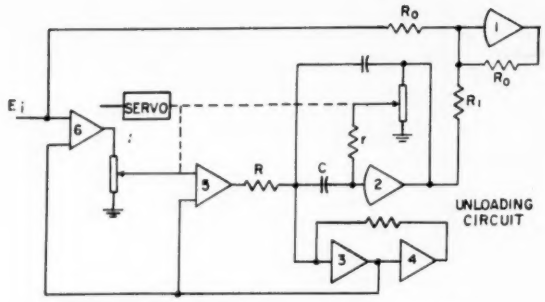


Fig. 7. Quadratic section requiring six amplifiers.

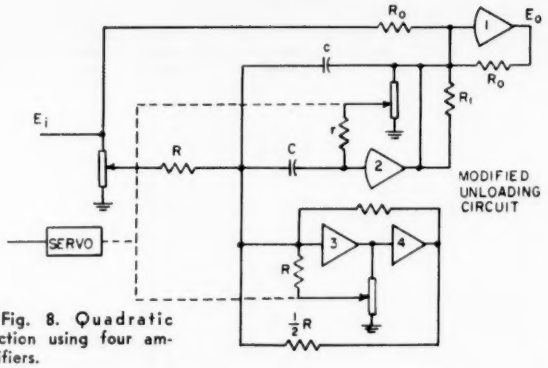


Fig. 8. Quadratic section using four amplifiers.

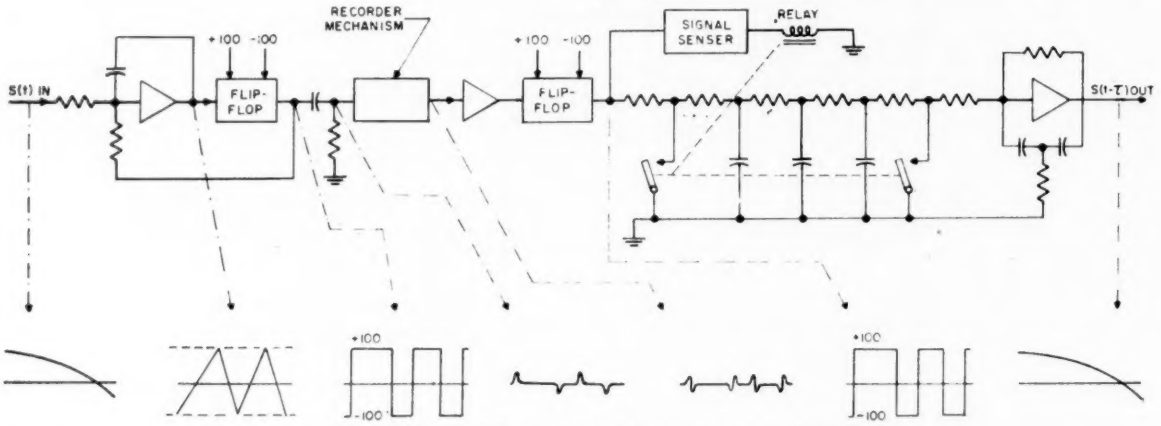


Fig. 9. Block diagram of RPI recorder, showing waveforms at each point.

the recorder are:

1. Accuracy of 0.1% of maximum signal at dc. Flat to 5 cps, down 1 db at 9 cps.
2. Noise level 60 db below maximum signal.
3. Dynamic range ±100 volts.
4. Considerable independence from mechanical imperfections and characteristics of tape, recording mechanism and recording head.
5. Overall simplicity of operation.

A block diagram of the system is shown in Figure 9. Time ratio modulation (similar to time division techniques) is used in order to obtain independence from the mechanical and magnetic properties of the recorder. A six-channel recorder using this principle has been constructed at Rensselaer Polytechnic.

Applications of the recorder include: (1) Time delay (with an adjustable read head) from 0.1 second to infinity. (2) Enlarging the effective capacity of the computer. A large problem can sometimes be subdivided into independent simpler problems. The results of these can be stored and later combined to obtain the required solution. (3) Recording more accurately than possible with strip chart recorders so that important information can be studied away from the computer at a later time. (4) Attainment of otherwise "unrealizable" filters. Playback in reverse order is used. (5) Solution of partial differential equations. One dimensional heat equation has been solved using time increments.

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Information (Without Theory)

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15. Storch, L., "Synthesis of Constant Time-Delay Networks Using Bessel Polynomials," Proc. I.R.E., Vol. 42, pp. 1666-1675, November 1954.

16. Stubbs, G. S. and Single, C. H., "Transport Delay Simulation Circuits" Westinghouse Electric Corp., Atomic Power Division, Report WAPD-T-38.

17. Thomson, W. E., "Delay Networks Having Maximally Flat Frequency Characteristics," Proc. I.R.E., Vol. 96, pt. III, p. 487, November 1949.

18. Thomson, W. E., "Networks With Maximally Flat Delay," Wireless Eng., Vol. 29, p. 256, October 1952.

19. Thomson, W. E., "Time Delay Circuits," Proc. I.R.E., Vol. EC-4, p. 74, June 1955.

20. Wallis, C. M., "Design of Low-Frequency Constant Time Delay Lines," Trans. A.I.E.E., Vol. 71, p. 135, 1952.

November 1956
B. Loveman
Reeves Instrument Corporation

* * *

Frank Smith came out to the house for dinner last nite and gave your Ed. a preview of the Second National Simulation Conference papers. Impressions: *Broad coverage—Efficiency*—The emphasis on *digital and combined simulation*—underscored by *five* IBM papers.

The attention to *function generation*, particularly of more than one variable—this is still a problem.

Computer Events

Other events on page 418

Eastern Simulation Council

Date: 22 March 1957

Place: American Mach. & Foundry Fawcett Bldg., Greenwich, Conn.

Subject: Simulation of Nuclear Reactors.

National Simulation Conference on Computers—Southwest Regional Conference and Electrical Show, IRE

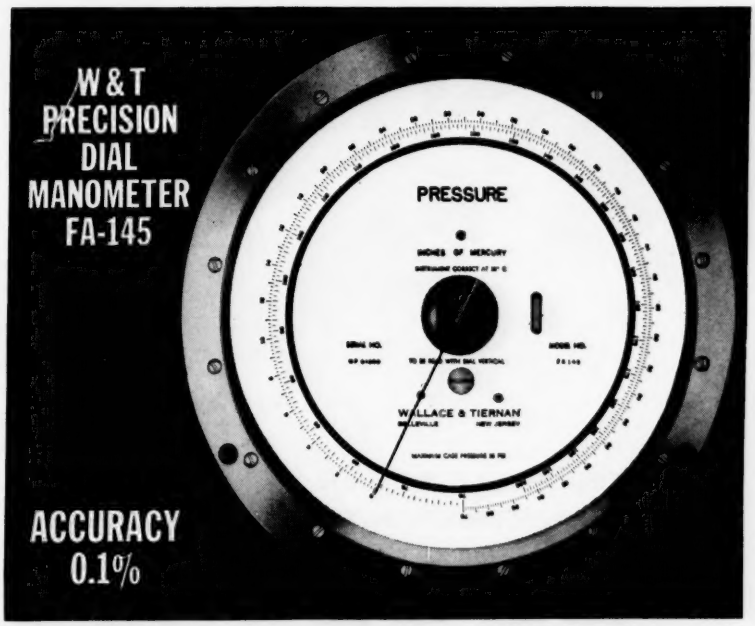
Dates: 11-13 April 1957

Place: Houston, Texas

Midwestern Simulation Council

Place: Houston, Texas

This meeting will be held in conjunction with the Southwestern IRE Conference and Exhibit at the Shamrock Hilton Hotel on 11-13 April.



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of Gauge, Vacuum or Differential Pressures on Pneumatic Systems

Accuracy:	1/1000 of full scale
Sensitivity:	1/10,000 in *all* ranges
Ranges:	0 to 120 inches of water (min.) 0 to 300 inches of mercury (max.) Other intermediate ranges available
Scale Length:	45 inch scale in two revolutions
Dial Size:	8½ inches

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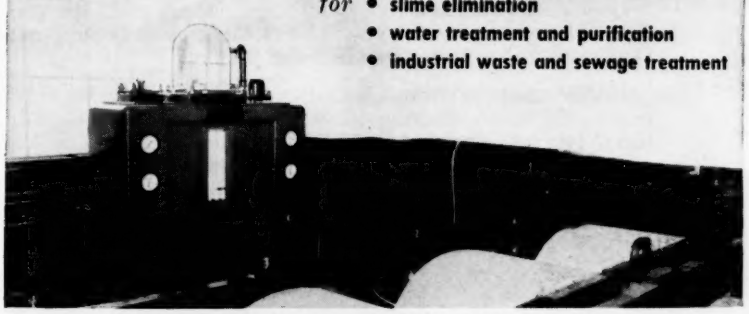

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For more information circle **64** on inquiry card.

BONNEVILLE POWER ADMINISTRATION SOLVES SWING EQUATIONS WITH

EASE*

How does an EASE* computer compare with the conventional network analyzer as an aid to electric power transmission engineering?

The answer from Bonneville Power Administration engineers at Portland, Oregon, is indeed favorable. Their Model 1032 EASE* has proved infinitely faster in the solution of swing equations and in studies of transient and steady-state problems of the vast Northwest power network.

EASE computer consisting of Model 1032 receptacle-control, 6 function generators and 20 amplifiers, installed at Bonneville Power Administration engineering offices, Portland, Oregon. Chief engineer is E. C. Starr; computer and systems engineer is Carl Gustafson.*

Interconnecting four of the world's largest hydroelectric projects and hundreds of fast-growing communities, this high-voltage (230 KV and up) network presents complex problems in stability. Speedy problem solution on the EASE* has already enabled BPA engineers to improve system stability, eliminating many outage problems, and to plan a variety of alternate switching paths to minimize circuit downtime.

Indications are that this EASE* installation has already paid for itself, with rosy prospects for a profitable future. Among coming studies BPA engineers plan for the versatile EASE* are:

1. Effect of machine excitation on system performance
2. Hydraulic governor speed control
3. Design problems in mechanical, civil and electrical engineering related to system improvement and future expansion

Good field service is a vital factor in satisfactory computer performance. It is supplied with EASE* by a nation-wide network of factory-trained Berkeley representatives; in this instance, Hawthorne Electronics of Portland and Seattle.

EASE* computation and simulation equipment ranges from the basic Model 1032 illustrated here to the advanced-design Model 1132 with DO/IT (Digital Output-Input Translator system). Two fully-equipped EASE* computation centers (Los Angeles and here at Richmond) are also available on a "for hire" basis. Full information on EASE* equipment and facility services is yours for the asking; please address Dept. B-3.

127

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HUGHES SILICON RECTIFIERS

Hughes introduces a new series of high-quality silicon rectifiers, especially designed for use in miniaturized circuitry. These new low-power rectifiers are characterized by low forward voltage drop, together with low back leakage. They are exceptionally efficient units in electronic power supplies and, in such applications, can be used in place of many conventional vacuum tubes.

The new Hughes Rectifiers feature: maximum AC input voltages up to 275 volts RMS; maximum reverse DC working voltages up to 375 volts; maximum average rectified forward current up to 200mA; maximum power dissipation (at 25°C) up to 200mW. Operating temperature range for all types: −75°C to +150°C.

PHYSICAL CHARACTERISTICS

All Hughes Rectifiers are packaged in a one-piece, fusion-sealed glass body. This famous construction is impervious to moisture penetration, ensures stable operation under severe operating conditions. Maximum dimensions, rectifier glass body: length, 0.265-inch; diameter, 0.105-inch.

Our sales engineers will welcome the opportunity to discuss applications of these new rectifiers with you. For the address of our sales office nearest you, or for more complete specifications concerning the new Hughes Rectifiers, visit Booths 2801, 2803, 2805 at the I.R.E. Show, or write:

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INSTRUMENTS and AUTOMATION

New Instruments

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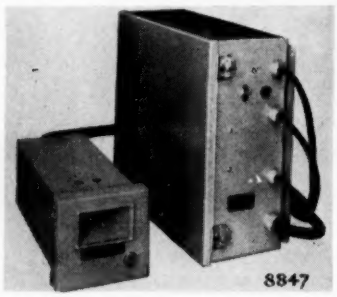
FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 581

ELECTRICAL and ELECTRONIC INSTRUMENTS

DIGITAL SERVO INDICATOR

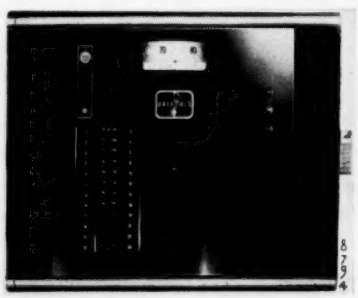
New null-balance "Model 143 Digital Servo Indicator" rapidly displays millivoltage or resistance changes developed by flow, weight, force, and temperature measuring elements; utilizes continuous null balance servo system of operation in a two-case cable-connected arrangement. Remote case incorporates (1) measuring circuit, (2) damping network, (3) amplifier, (4) converter and (5) power supply when necessary. Panel-mounted indicator requires less than one-quarter panel space of a standard scale indicator, contains (1) balancing motor (2) slidewire and (3) digital counter. Among other features: maker's "Stabilized Digital Servo System" limits rollover of last digit wheel.—*Gilmore Industries, 5713 Euclid Ave., Cleveland 3, Ohio.*


8847

For more information circle **201** on inquiry card.

MULTIPLE INDICATOR

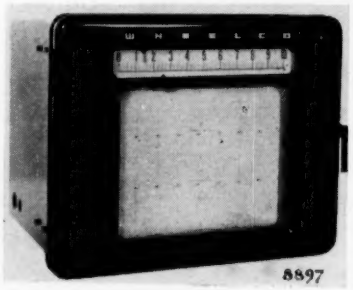
New "Drum-Type Precision Indicator" for quick readings of variables at remote points is available in resistance-thermometer and pyrometer models for temperature, also for measuring other variables. Instrument uses maker's standard "Dynamaster" electronic instrument components; is equipped with numbered push button switches on case front and can scan up to 48 remote points. Rotating-drum-type scale has a calibrated length of over 26". Full-scale travel takes 4½ seconds.—*The Bristol Co., Waterbury 20, Conn.*



For more information circle **202** on inquiry card.

MULTIPOINT RECORDER

New "Series 8000" can record up to sixteen points on one chart; is of null-balance potentiometer type; can incorporate up to six limit switches to provide for high and/or low signal indication. Up to four switches can have common front set; additional switches are independently adjustable. Indicating scale has 11" calibrated width (illuminated when specified); cross-chart speed 4 seconds; chart speeds depend on number of points; cycle time 5 seconds; single or multicolor color printing; automatic standardizer with 5-sec period every 40 min; sensitivity 5 microvolts for scale spans of 5 mv or less (0.1% for scale spans wider than 5 mv); accuracy 0.25% for most scale spans.—*Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.*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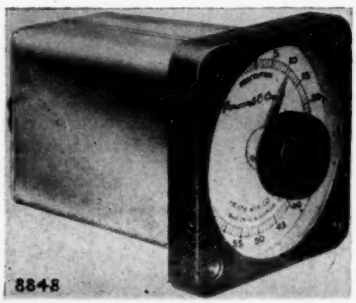
For more information circle **203** on inquiry card.

CURRENT-INPUT CONTROLLER

New "Model 75 Percent O-Cycle Timer" is a time-on time-off percent type of automatic controller with dial calibrated from 0% to 100% ON-time. Standard basic cycles from 15 sec to 8 hr. Loads up to 25 amp @ 150 v 60 cps can be handled without auxiliary equipment.—*Hagen Mfg. Co., Inc., 202 20th St., Moline, Illinois.*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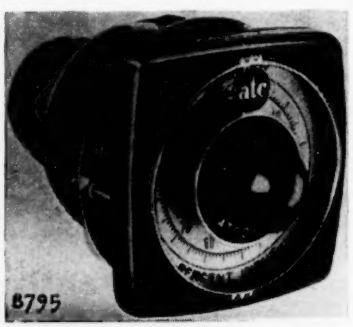
For more information circle **204** on inquiry card.

CURRENT-INPUT CONTROLLER

New "Type J-4A Atcotrol" is added to maker's line of time-on time-off percent type of automatic controllers with dials calibrated from 0% to 100% ON-time. Standard basic cycle is 60 sec (30 sec and 15 sec also available). Choice of synchronous motors for 115 or 230 v; 25, 50 or 60 cps. Heavy-duty ⅜" self-cleaning sp-st silver contacts carry 25 amp @ 115 vac, 20 amp @ 230 vac. Various housing, dial and mounting options.—*Automatic Temperature Control Co., Philadelphia 44, Pa.*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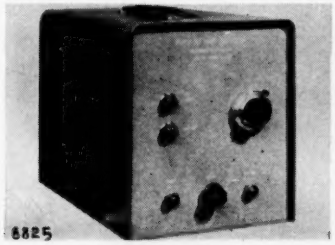
For more information circle **205** on inquiry card.

LIMIT CONTROLLER

New "Model 561 Limit Controller" provides monitoring, and/or control of variables measurable by differential

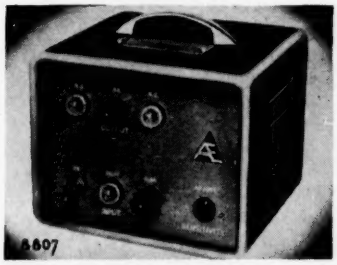


transformer pickups. Any desired control point in range of a standard pickup can be preset on a ten-turn dial. Thereafter, output relay closes whenever input variable equals or exceeds preset limit and opens when it falls below limit. Operating time is about 0.05 sec. Relay contacts operate panel lamps and external alarm or control devices. Null-balance principle gives stable repeatability of 0.000025" or 0.1% of pickup span. Linearity 0.1%. —*Daytronic Corp.*, 216 *South Main St., Dayton* 2, *Ohio.*

For more information circle **206** on inquiry card.

ELECTRONIC CONTROL UNIT

New "6330 Controller" standardized portable miniature control unit, developed for inclusion in electronic control



systems, lowers costs through standardization, and obviates time lost in designing and fabricating special units. Essentially an ultrasensitive heavy-duty electronic switch, it will control up to 500 watts, either delivered at 115 vac 60 cps, or switched by its internal contacts. Minimum input impedance is 2 megohms. Rear-mounted terminal strip provides maximum flexibility for selection of switching functions.—*Autron Engineering, Inc.*, 1254 *West Sixth Street, Los Angeles* 17, *Calif.*

For more information circle **207** on inquiry card.

DIGITAL COMPARATOR

New digital comparator, for use in digital servo control systems, makes possible true digital control without recourse to counting techniques. In conjunction with maker's 13-bit or 19-bit shaft position encoder, it can provide digital control through conven-

Extra Large Capacity

— High Vacuum —

TWO-STAGE

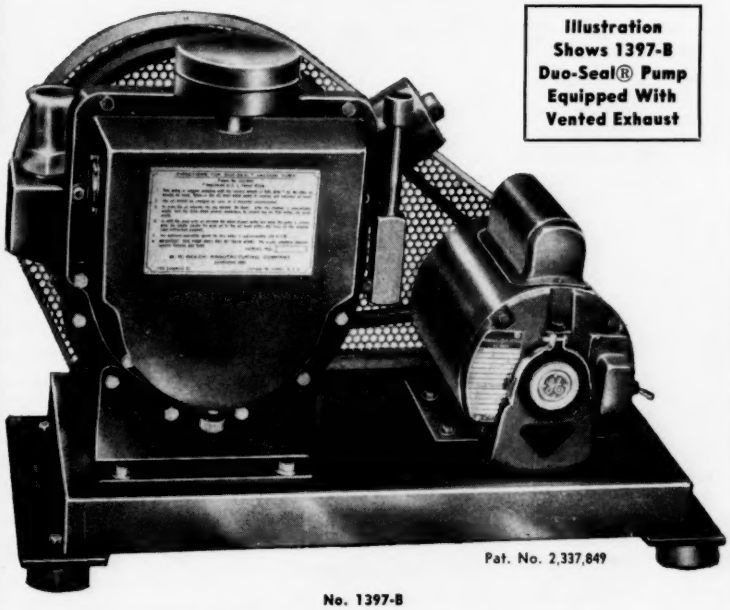
DUO-SEAL® VACUUM PUMP

***with* VENTED-EXHAUST**

PATENT PENDING

• Reduces pumpdown time

Illustration Shows 1397-B Duo-Seal® Pump Equipped With Vented Exhaust



No. 1397-B

★ Vented Exhaust Permits Pumping of Most Condensable Vapors

★ Eliminates Use of Traps or Oil Separators in Systems Containing Water or Other Condensables

★ Reduces Number of Oil Changes Required

1397B. DUO-SEAL VACUUM PUMP, Motor Driven.
For 115 Volts, 60 Cycles, A.C. **Each, $625.00**

1397C. DUO-SEAL VACUUM PUMP, Motor Driven.
For 230 Volts, 60 Cycles, A.C. **Each, $625.00**

1397D. DUO-SEAL VACUUM PUMP, Motor Driven.
For 115 Volts, D.C. **Each, $697.50**

A belt guard is included with the mounted pumps.

1397. DUO-SEAL VACUUM PUMP, Unmounted.
With pulley, but without motor, belt or base. **Each, $52.00**

Pump Revolutions - 300 RPM
Motor - ¾ HP - 1725 RPM
Tubing Required - 1⅝-inch i.d.
Over-all Dimensions of Mounted Pump 25⅝ x 14¾ x 18¾ inches high
Belt-tightening Provision
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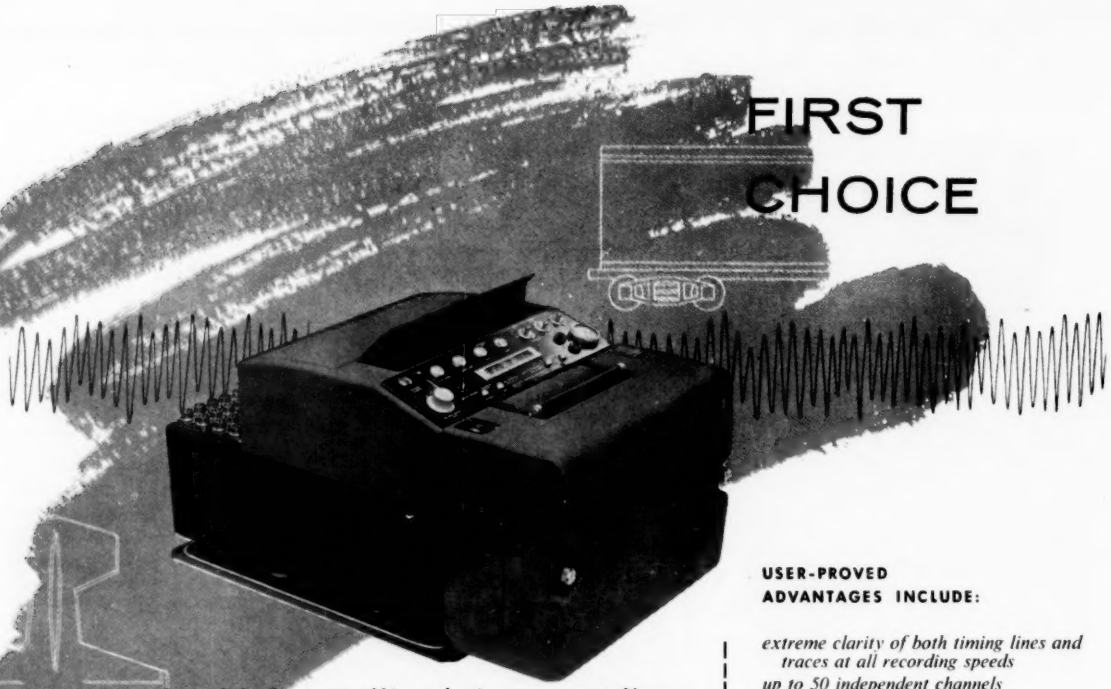


. . . for high-quality data recording

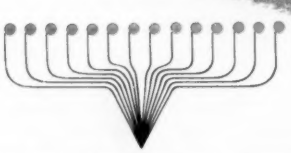
Consolidated's 5-119 Recording Oscillograph was developed to fill user-specified requirements for an exceedingly reliable instrument with great data capacity. The most advanced instrument of its type, the versatile 5-119 provides excellent records in mobile and flight testing applications where severe shock, vibration, and temperatures are commonplace. Throughout industry, it serves as the foundation of successful design-engineering-performance programs.

USER-PROVED ADVANTAGES INCLUDE:

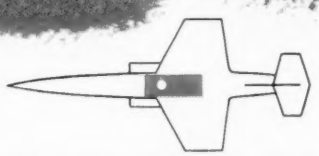
extreme clarity of both timing lines and traces at all recording speeds
up to 50 independent channels
wide record speed range
wide frequency range
adjustable scanning speed
automatic record numbering
automatic record-length control
record footage indicator
temperature-controlled galvanometer block
positive gear drive system
built-in shockmount base
quick-change magazines
two independent recording banks
reserve recording lamps
centralized, single-surface controls
automatic warning and safety systems
choice of a-c or d-c models

For complete specifications, please contact your nearby CEC field office, or write for Bulletin CEC 1536B-X10

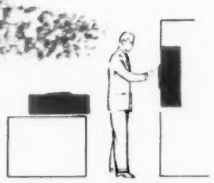
CEC RECORDING OSCILLOGRAPH



FLASH TIMING SYSTEM permits absolute timing with external timing pulses. CEC's new Flash Timing System synchronizes timing lines of from 2 to 100 remotely located oscillographs, permits quicker, more accurate interpretation of recorded data.



NEW EXPLOSION-PROOF DESIGN meets safety requirements of military aircraft specifications for test instruments in hazardous locations. This optional modification (5-119P7-50-MB) is available for 400 cycle, 200 volt, 3-phase operation. See Bulletin mentioned above.



OPTIONAL RACKMOUNT is ideal for permanent instrumentation, provides vertical mounting and effective shock isolation for the 5-119 in mobile applications. Even when tilted for adjustments or magazine loading, the 5-119 extends only 13" from front of rack.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

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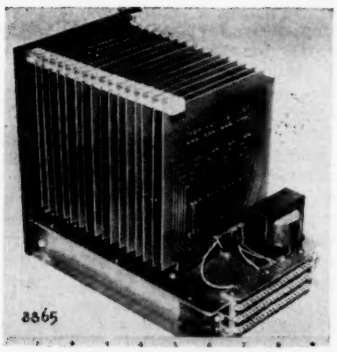
For more information circle **45** on inquiry card.

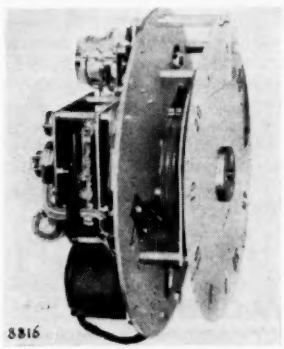


tional servo amplifiers and motors. This enables application of digital control to existing servo systems with least change of components. Using no relays or tubes, comparator can be readily packaged for rugged environments and with great flexibility of configuration.—*Norden-Ketay Corp., Commerce Road, Stamford, Conn.*

For more information circle **208** on inquiry card.

POTENTIOMETER OR BRIDGE SERVOMECHANISM

New self-balancing "Dynamaster Servomechanism," furnished without a case and designed to be built into



a user's equipment, comprises standard "Dynamaster" instrument parts on a circular base and, when used with maker's amplifier, input transformer, and "Syncroverter" dc-ac inverter, forms a complete self-balancing dial indicator. It is available as a potentiometer or as an ac bridge, with dial indicator speeds of 1, 3, and 4½ seconds. Alarm switch and retransmitting slidewire are optional. Among applications: replacement for direct-deflection instrument where better accuracy or reliability is required, or self-balancing unit to operate analog-to-digital conversion mechanisms for readout.—*The Bristol Company, Waterbury 20, Conn.*

For more information circle **209** on inquiry card.

PROCESS REFRACTOMETER

New model of "Goldberg Process Refractometer" is especially useful for soluble-solids control of turbid,

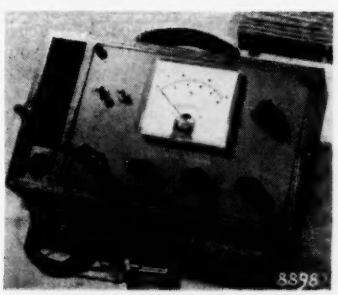
dark-colored concentrates likely to occur in manufacture of certain food products. Three models are available (in Brix ranges of 0-25%, 12-72%, 36-82%), any one of which can be installed in side-wall of a process vessel, product pipe line or other location where continuous reading is required; or conveniently attached to a fixture mounted on an overhead track. Distinctive advantages include: electrically illuminated scale; evaporation errors eliminated; readings unaffected by viscosity, foam, air bubbles, and pulp; no operator training period required; accuracy 0.25% to 0.5%; unique optical system produces sharp transition line on large 0.5% graduated scale; windshield wiper always brings a fresh product sample to prism face.—*American Optical Co., Instrument Div., Buffalo 15, N. Y.*

For more information circle **210** on inquiry card.

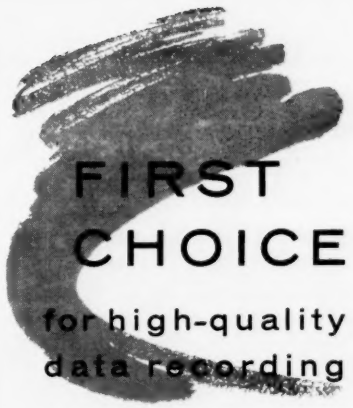
TEMPERATURE, HUMIDITY

RADIATION THERMOMETER

New wide-range model of Thermistor Radiometer permits relative or absolute temperature readings from surfaces of equipment, human or animal skin, building walls, liquids, etc.; also sky and ground temperatures; utilizes Stefan-Boltzman fourth-power blackbody radiation law. Among features: reference blackbody for ambient temperature compensation; self-compensating thermistor bridge circuit contained in head; 20° field of view allowing selectivity in measurement of distant objects; rapid-re-



sponse thermistors for quick scanning of surfaces to measure temperature



CEC's Recording Oscillographs deliver unexcelled accuracy for exacting users throughout the world. There's a quality oscillograph for *your* specific requirement.

5-114 is available in either 18- or 26-trace capacity models with preferred quality features. Described in Bulletin CEC 1500C-X13.

5-116 features 14-trace capacity, a-c or d-c. Economical and highly versatile. Please write for Bulletin CEC 1521A-X9.

5-117 records 6 separate phenomena on 70-mm paper. Precision throughout, small, low-cost. Bulletin CEC 1533B-X10.

5-118 is designed for applications demanding extremely small size and light weight. Please write for Bulletin CEC 1531-X3.

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For more information circle **69** on inquiry card.

differences as small as 0.1 C°; circuits permit full-scale readings of 10, 30, and 100 C° above or below ambient.—*Williamson Development Co., 317 Main St., West Concord, Mass.*

For more information circle **211** on inquiry card.

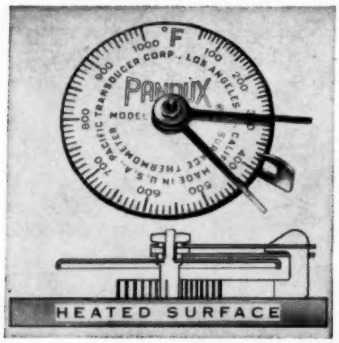
TEMPERATURE CONTROLLER

New "Type B27A" dual switch controller can often substitute for two separate single-switch controls. Immersion element (bellows housing) is placed into medium to be controlled. Control head has external range adjustment with calibrated scale. Models with ranges of 50 F° or 100 F° between limits of 30°F and 400°F are available. Use of two switches in one controller saves space and cost, provides extreme flexibility of switching arrangement, permits control of two independent circuits, and also permits switch action above and below set point. Internal adjustment screw on each switch makes it possible to adjust for a maximum span of about 20 °F between switch settings. This span is constantly maintained throughout control range.—*United Electric Controls Co., 79 School St., Watertown, Mass.*

For more information circle **212** on inquiry card.

MAXIMUM-MINIMUM SURFACE TEMPERATURE THERMOMETER

New stainless steel "Model 575M" with a range of 50°F to 1000°F, has maximum and minimum pointers that



can be reset after taking a reading, and an Alnico magnet for attachment to ferrous surfaces when thermometer is used in a vertical position.—*Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.*

For more information circle **213** on inquiry card.

FIRE DETECTOR

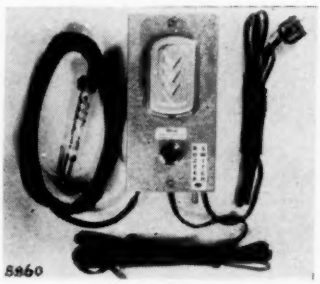
New "Model 27021-11" baggage compartment fire detector (currently being installed in all Class D baggage compartments of new DC-6 and DC-7 aircraft) is a thin-shelled stainless-steel hermetically-sealed unit weighing about 4.3 oz; has adjustment range of 50°F to 350°F; can withstand exposure to −65°F indefinitely

and to 2000°F flame for short periods.—*Fenwal Inc., Aviation Products Div., Ashland, Mass.*

For more information circle **214** on inquiry card.

HIGH-TEMPERATURE ALARM

New "Thermo-Alarm" is an easy-to-install self-contained automatic alarm unit that sounds a buzzer when



an unsafe temperature is reached in refrigerators, sterilizers, incubators, etc. It plugs in to 110-115-vac 60-cps outlet; has an optional fail-safe remote telephone hookup and a 115 vac remote signal feature.—*Mack Electric Devices, Inc., Wyncote, Pa.*

For more information circle **215** on inquiry card.

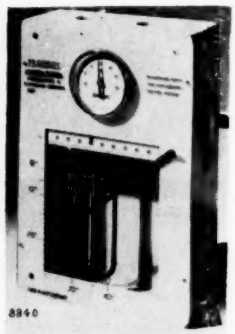
TEMPERATURE LIMIT SWITCH

New "Type E5GX High Limit Safety Temperature Control," designed to be connected in series with a primary temperature controller, is UL approved for 15 amp @ 115/230 vac in stand-by service (Underwriters' File No. E10667) and complies with requirement of 100,000 cycles at full load and at frequency of 5 cycles per minute. Built-in pilot light warns operator that safety control has cut off heat. By pressing reset button, circuit will be restored only if temperature has dropped below danger zone.—*United Electric Controls Co., 79 School St., Watertown 72, Mass.*

For more information circle **216** on inquiry card.

DIFFUSION HYGROMETER

New "Essco Hygrotherm," said to be accurate to 1% relative humidity, utilizes principle of vapor diffusion



through a porous wall separating room atmosphere from a chamber with distilled water at bottom. Each instrument is individually calibrated and re-tested. No maintenance other than adding distilled water every two or three months.—*Empire Scientific Supply Co., P.O. Box 85, Springfield Gardens 13, N. Y.*

For more information circle **217** on inquiry card.

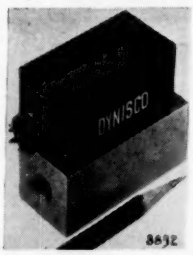
PRESSURE AND VACUUM

PRESSURE TRANSMITTER

New inexpensive "Model 44" indicating pressure transmitter, accurate to 0.5% of scale range, transmits a 3-15-psi air signal to indicating, recording or controlling instruments; is available in ranges from 0-30" Hg to 0-6000 psi with appropriate pressure elements from maker's standard line: spirals, helicals, bellows and diaphragms; also element materials for corrosive process fluids. Red pointer and 4⅛" black-on-white scale are visible from as far away as 20 ft. Universal mounting bracket for mounting on wall surface or on vertical pipe. Air connections are ¼" NPSF; measurement connection ¼" or ½" NPT, depending on pressure range.—*The Foxboro Co., Foxboro, Mass.*

For more information circle **218** on inquiry card.

DIFFERENTIAL PRESSURE PICKUPS FOR ACIDS, etc.



New differential pickups, in which a dry unbonded strain-gage element is isolated from pressurized fluid, are suitable for applications in rocket engines, chemical processing systems, etc., in conjunction with corrosive or conductive fluids. Only Teflon and stainless-steel parts come in contact with pressurized fluid. Models are available with ranges from ±0.5 psi to ±1000 psi at line pressures up to 2000

COMPUTERS AND PROCESS CONTROL discussed by *Eric Weiss*

The application of digital computers to the direct control of processes brings up these two questions: (1) Can the control functions be properly formulated? (2) Can computers be made reliable enough?

Speed is no problem. Today's memory developments offer practically instantaneous access. A 50 kc or 100 kc serial computer is fast enough to satisfy most control operations. When this is not fast enough, the overall speed can easily be increased one or two orders of magnitude through the use of a parallel machine.

There is another way of speeding up a computer. Rather than build a general purpose machine which can compute any problem we like to code into it, special purpose computers can be designed and built for special jobs. The same proven elements would be utilized, but would be arranged in different arrays in order to come up faster and more directly with the desired solution. The resulting machine would most likely do the job faster without actually increasing the repetition rate.

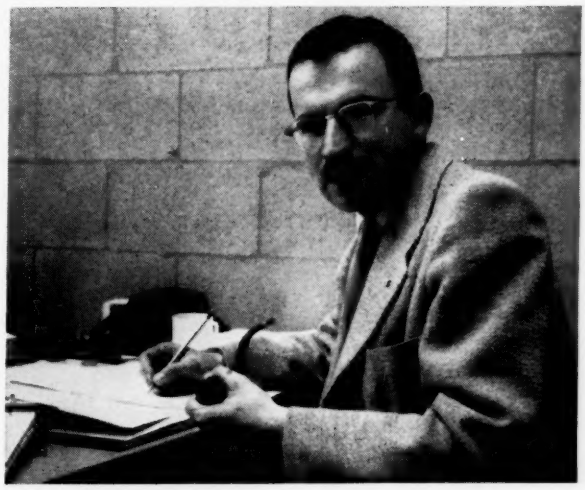
The problem of reliability is not so easily disposed of. In the past, digital computers were primarily used as mathematical tools to compute lengthy mathematical problems or to process repetitive data. If a computer made an error once every billion operations (which at the rate of 100 kc would be every three hours), it was not too serious. The error was caught and the problem, at the worst, computed again.

The moment we start thinking about a computer in direct control applications, the problem becomes more critical. If the computer controls some sort of manufacturing or chemical process, a single error at the wrong time in the wrong spot can be catastrophic. Under such circumstances, an error probability of 1 in a billion cannot be tolerated. An almost errorless operation is required.

Most digital computers presently in production have a large number of hot vacuum tubes. These are the least reliable elements in a computer. Their filaments burn out; envelopes leak; or various fragile elements short.

During the last decade, a series of solid state elements has been developed which make it feasible to build a computer without vacuum tubes or moving elements. The diode, the transistor, the magnetic amplifier, the magnetic core and several other elements in this class can be expected, unless abused, to live and operate without mistakes practically indefinitely. Furthermore, they are considerably smaller, lighter, and less power consuming.

Consider a flip-flop, for example. Utilizing vacuum tubes, a flip-flop consists of at least a double triode, several crystal diodes, resistors, capacitors, plus the necessary hardware to mount the same. Such an assembly normally occupied the same space as a king-size package of cigarettes, and the required accessory equipment, such as power supply or air conditioning, occupied a similar space. In contrast, a transistor flip-flop could be packaged in a volume of the size of a peanut shell with the corresponding power supply even less. The power consumption is so minute that the unit can be potted and it is quite likely in the near future a whole computer could be potted.



Eric Weiss, nationally-recognized authority on computer philosophy and design, discusses the use of digital computers in process control.

The major obstacle to the use of computers in control applications is the lack of understanding of the processes which are to be controlled. A scientist can play with a general purpose computer in a control system. He can code it by trial and error. Once the formulae have been determined, a special purpose computer that would be smaller, faster, and more efficient, can be built to control the process.

By applying the latest proven techniques, our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write us.

DAYSTROM SYSTEMS
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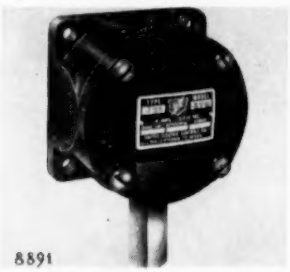
For more information circle **70** on inquiry card.

psi; operating with ac or dc excitation at 6, 12 or 15 v with bridge resistances of 350, 600 or 800 ohms and minimum full-scale outputs of 20, 40 or 50 mv respectively. Accuracy 0.5% of full scale at 70°F; operating temperature range −65°F to 350°F.—*Dynamic Instrument Co., Inc., Cambridge, Mass.*

For more information circle **219** on inquiry card.

PRESSURE-VACUUM SWITCH

New "Type J95 Control" has been designed for use in locations where explosive vapors or gases are present



8891

(Class I, Groups C and D locations). It is an uncalibrated unit, pressure settings being made by means of an internal adjusting nut. Models are available with various adjustable ranges between limits of 0 and 500 psi, and maximum pressures of up to 600 psi. On-off differentials between limits of 2 and 30 psi are obtainable. Basic components: pressure assembly and snap-acting switch. Three standard switches: normally-open, normally-closed, or double throw with no neutral position. Switches are rated for 15 or 20 amp. @ 115 or 230 vac. Dc switches also available.—*United Electric Controls Co., 79 School Street, Watertown, Mass.*

For more information circle **220** on inquiry card.

PRESSURE SWITCH

New hydraulic and pneumatic pressure switch is adjustable from 0 to 1200 psi; withstands 3000 psi without distortion of pressure element. Made of cast aluminum alloy (st. steel also available), unit is totally enclosed and weatherproof, uses any Micro switch, 15 amp 120 to 460 vac with sp-dt silver contacts—also available for dc application.—*Alloy Bellows Engineering Co.*, 18125 *Roseland Rd, Cleveland* 12, *Ohio.*

8706

For more information circle **221** on inquiry card.

PRESSURE REGULATORS

New "660 Series" line pressure regulators have a relief mechanism that automatically relieves a build-up of back pressure on delivery side that exceeds set delivery pressure. Series comprises four styles, delivery pressure ranges of 0-40 psi or 0-150 psi and flow rates up to 2500 cfh.—*Hoke, Inc.*, 231 *S. Dean St., Englewood, N. J.*

8352

For more information circle **222** on inquiry card.

GAGE PROTECTOR

New "In-Line Gauge Saver" automatically shuts off gage when system pressure goes beyond maximum oper-

DATA REDUCTION INSTRUMENTS

$ 1495

DIGITAL VOLTMETER MODEL 100-A

- **PEAK DETECTOR**
- **HOLDING AMPLIFIER**
- **STABILIZED D.C. AMPLIFIER**

1. All electronic system
2. High accuracy—3 digit-0.1%—4 digit 0.01%
3. High reading speed 70/sec or 700/sec
4. High reliability
5. Minimum adjustment
6. Mount in 19" racks

Units can be used for spectrophotometer and mass spectrometer PEAK READING, High accuracy digital AC VOLTMETER as well as various AC and DC analog to digital conversions

ELECTRONIC COMPUTER CO.

6191 Ridge Avenue **Phila. 28, Pa.**

Write for literature

For more information circle **76** on inquiry card.

DEHYDRATION OF GASES

HI-LO PRESSURES

HI-LO FLOWS

- New Leakproof Design — Chambers and Cartridges "O" Ring sealed, no possibility of gas bypassing the cartridge.
- No tools required to change cartride or Mechanical Filter Element for cleaning.
- Manual or Automatic Units. Portable, stationary or airborne installations.

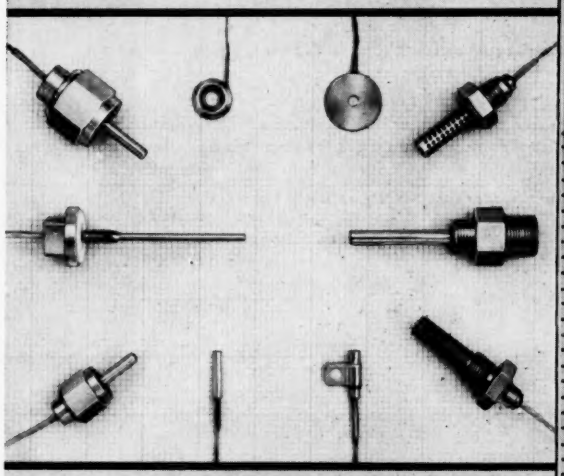
ROBBINS AVIATION

WRITE FOR BULLETIN

1735 W. FLORENCE AVE. LOS ANGELES 47, CALIF.

For more information circle **77** on inquiry card.

For the highest degree of *Accuracy* in AIRBORNE TEMPERATURE INSTRUMENTATION



HIGH OUTPUT • RESISTANCE-TYPE TRANSDUCERS

Arnoux high resistance temperature probes are designed for telemetering and other applications requiring high signal levels. Models are available in a wide variety of physical configurations for measuring surface, fluid, and air temperatures.

- Output up to 5 volts without amplification.
- −320°F to +500°F range with ±2% linearity. (Special units are available up to 1600°F.)
- Nominal resistance values: 100 to 20,000 ohms.
- May be used in AC or DC Bridge circuits.
- Meets MIL-E-5272A specifications.
- Calibration curve supplied with each probe.

When used with ARNOUX miniaturized companion "TME" system, 20K transducers provide 5 volts output for as little as 150°F change.

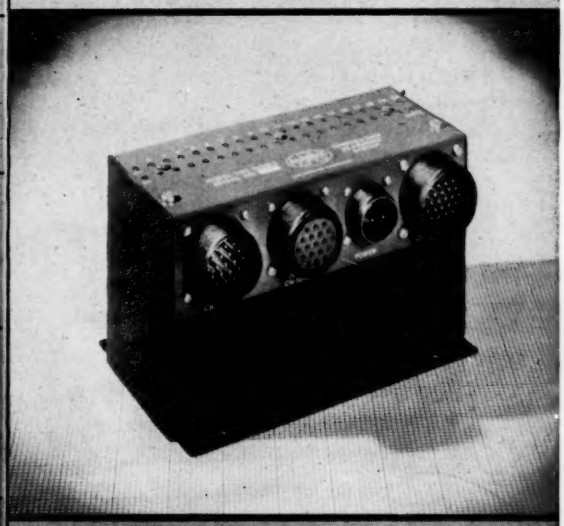
Write for Bulletin 300

MINIATURE MULTI-CHANNEL TEMPERATURE MEASUREMENT SYSTEM... full scale output 5 volts

ARNOUX "TME" is a completely self-contained system designed for operation with ARNOUX special resistance-type transducers. Models are offered in 7, 14, and 20 channel capacity. The unit contains two precision mag-amp type, regulated D.C. power supplies, series connected with common neutral, for excitation of the transducers in half bridge circuitry.

- Power requirement: 115 volts, 400 cps.
- Power consumption: 20 channel model requires less than 20 watts.
- Balance and attenuation controls for each channel.
- No vacuum tubes or transistors used.
- Output voltage and impedance characteristics — directly compatible with F.M. sub-carrier and P.W.M. coder input requirements.
- System stability: within 1% throughout MIL-E-5272A environmental.
- Dimensions: 20 channel model: 7" x 4¼" x 3", wt. 5½ lbs.

Write for Bulletin 300



ARNOUX... *foremost* **in TEMPERATURE MEASUREMENT EQUIPMENT... ...TRANSDUCERS, ACCESSORIES AND CUSTOM ENGINEERED SYSTEMS.**

ARNOUX CORPORATION

Designers and Manufacturers of Precision Instrumentation

11924 W. WASHINGTON BOULEVARD • LOS ANGELES 66, CALIFORNIA

For more information circle **71** on inquiry card.

Research and development at Lockheed Missile Systems Division laboratories in Palo Alto is of a most advanced nature. Particular areas of interest include microwaves, telemetering, radar, guidance, reliability, data processing, electronic systems, instrumentation, servomechanisms. Inquiries are invited from those qualified by ability and experience for exploratory efforts of utmost importance.

Here members of the Electronics Division discuss systems radar problems related to measurement of missile trajectories. Left to right: K. T. Larkin, radar and command guidance; Dr. S. B. Batdorf, head of the Electronics Division; Dr. H. N. Leifer (standing), solid state; Dr. R. J. Burke, telemetering; S. Janken, product engineering.

Lockheed

MISSILE SYSTEMS DIVISION

research and engineering staff

LOCKHEED AIRCRAFT CORPORATION

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CALIFORNIA

I·R·E
NATIONAL CONVENTION AND RADIO SHOW

Significant developments at Lockheed Missile Systems Division have created new openings for:

Controls Systems Engineers – to analyze and synthesize complex automatic control systems.

Inertial Guidance Engineers – to perform systems analysis and design of inertial guidance systems.

Infrared Specialists – to perform preliminary systems design and parametric optimization of advanced infrared detection systems.

Data Processing Systems Specialists – to perform advanced system development and design in new techniques of automatic data processing.

Weapons Systems Specialists – to perform basic analysis and systems evaluation of advanced weapons systems.

Electronic Product Engineers – to translate laboratory electronic systems into prototype models meeting the rigid requirements of modern weapons systems.

Radar Systems Engineers – to develop advanced radar systems associated with guided missiles.

Theoretical Physicists – to analyze propagation of electromagnetic waves through the ionosphere and through dielectric materials and study radiation problems pertaining to advanced antennas in the microwave and millimeter domain, including scattering problems related to the reflection of electromagnetic waves from simple and complex boundaries.

Experimental Physicists – to investigate microwave circuit components including ferrites and various millimeter wave techniques such as MAZUR.

Antenna Specialists – to design and develop airborne antennas and radomes for high speed missiles for telemetering, radar, and guidance systems application.

Video Specialists – to develop advanced systems for the transmission of visual data by electronic means.

Circuit Design Specialists – to design telemetering and guidance systems utilizing advanced circuit components.

Positions are open at the Palo Alto Research Center and Sunnyvale and Van Nuys Engineering Centers. M. H. Hodge, M. W. Peterson and senior members of the technical staff will be available for consultation at the convention hotel. Phone PLaza 14860 or 14861.

Lockheed

MISSILE SYSTEMS DIVISION

NEW INSTRUMENTS

ating limit; reconnects when pressure drops to within gage limits. Compression spring can be adjusted to accommodate minor changes. Standard units have ¼" male tube inlet connection and ¼" male tube or ¼" female pipe outlet connection; available from stock in all shut-off pressures from 60 to 3,000 psi. Operating temperature range −65°F to 160°F; maximum operating pressure 5,000 psi.—*Fisher Controls Inc., 1222 Seventh St., Santa Monica, Calif.*

For more information circle **223** on inquiry card.

FLOW-RATE, VOLUME

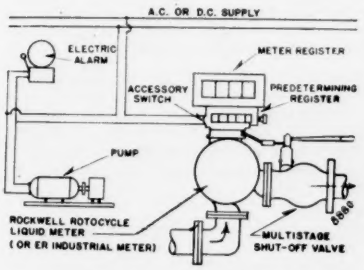
METERING PUMP

New "Model 1105" low-cost positive-displacement low-capacity medium-pressure unit accurately proportions various solutions or chemicals; is available in six types with capacities from 0.12 to 20 gph. Volumetric accuracy of 1% is guaranteed from maximum to one-fifteenth of maximum displacement.—*Porportioners, Inc., 345 Harris Ave., Providence, R. I.*

For more information circle **224** on inquiry card.

AUTOMATIZED DISPENSING

New explosion-proof control system for industrial liquid metering provides for automatic switch control of

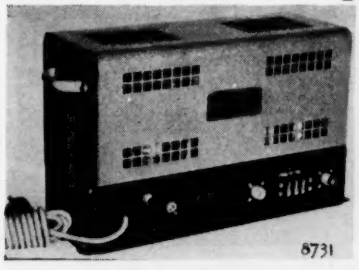


all pumps and quantity-control valves at meter. Upon completion of a predetermined liquid delivery, a switch automatically opens a circuit and simultaneously cuts off all liquid flow at meter and all pumping action. For repeated deliveries of a fixed amount of liquid, a factory-set predetermining register automatizes dispensing to barrels, mixing tanks, etc.—*Meter & Valve Div., Rockwell Mfg. Co., Pittsburgh 8, Pa.*

For more information circle **225** on inquiry card.

FLOW-RATE CONVERTER

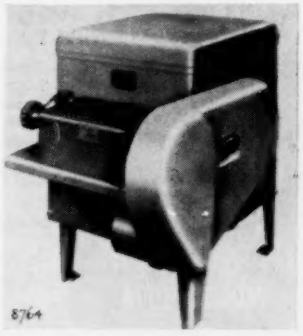
New transient converter for use with turbine type flowmeters accepts a sinoidal type input signal of varying frequency and provides either a voltage output for recorders and oscillographs or a digital output to counters and computers. Input frequency range 0-600 cps operating from a 500-ohm source impedance; output 0-100 mv or 10-v positive pulse (at 8 times input frequency). Short term analog accuracy and linearity 0.5%; long-term accuracy 3%; digital accuracy is absolute.—*Fischer & Porter Co., 950 Jacksonville Road, Hatboro, Pa.*



For more information circle **226** on inquiry card.

CONTINUOUS VOLUMETRIC LIQUID FEEDER

New wide-range corrosion-resistant "Model 65 Rotodip" is especially adapted to handle acids, alkalies and

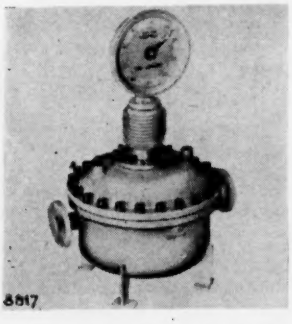


slurries; features versatility, simple design, accuracy better than 1%, low maintenance, and adaptability to automation.—*Omega Machine Co., 345 Harris Ave., Providence 1, R. I.*

For more information circle **227** on inquiry card.

POSITIVE-DISPLACEMENT FLOWMETER

New "VAF-Brooks" positive-displacement flowmeter, of four-piston type, is suitable for hard-to-handle



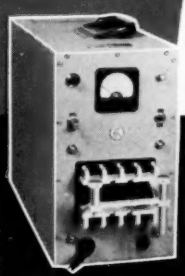
from
Magnet Charger
HEADQUARTERS

MODEL 942
Recommended by Leading Magnet Makers

3 VERSATILE MODELS

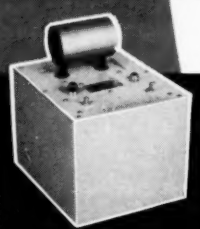
For saturating Alnico magnets weighing up to 34 lbs. and high flux ceramic magnets of any shape or pole configuration. Operates on condenser discharge principle from regular 115-volt, 60-cycle line.

Charging outputs from 100,000 to 200,000 ampere-turns through plug-in transformers, up to 3600 watt-seconds using wire-wound fixtures. Adapters for multi-pole rotors, rod, bar, ring and various other shapes available. Designed for continuous production use with low power consumption. Price of basic unit is less than $2100.



MODEL 107A

A basic condenser discharge unit for most medium size magnets, the Model 107A provides ranges of 12,000 and 24,000 ampere-turns. It is capable of saturating most instrument magnets, including the new core type mechanisms, using adapters or wire-wound fixtures. Designed for continuous duty. Operates from 115-volt, 60-cycle line. Price $530.



MODEL 1221

A low cost, condenser discharge unit employing novel, plug-in wire-wound type charging fixtures, the Model 1221 is designed for the user of small magnets. Its 10,000 ampere-turn output will saturate about 2" of Alnico V. Charging cycle rate is approximately 3 seconds, continuous duty, operates from 115-volt line. Price $180.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.

WE CAN HELP YOU

12 years' magnet charging experience is yours for the asking—send for illustrated data sheets.

RFL Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

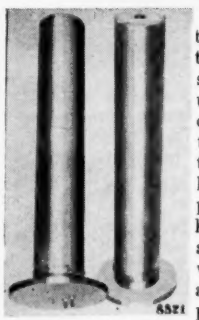
For more information circle **72** on inquiry card.

fluids such as bunker oils, still bottoms and asphalt; is available in sizes from 1" to 6" or up to 450 gpm capacity, temperatures up to 660°F and pressures up to 600 psi. Guaranteed accuracies ¼% in 1" sizes, and ½% in 2" to 6" size meters.—*Brooks Rotameter Co., Lansdale, Pa.*

For more information circle **228** on inquiry card.

LIQUID LEVEL

LEVEL INDICATORS FOR LIQUID METALS



New temperature-compensated transmitters sense level of liquid sodium and other liquid metals at temperatures to 1300°F; have no moving parts; contain a hollow bore sealed at top; can be welded into top of a receptacle with probe extending downward into liquid metal. Rise and fall of liquid metal in bore of probe are sensed by pickup coil system around bore. Ranges are available from a few inches to 30 feet.—*Crescent Engineering & Research Co.*, 5440 *N. Peck Rd., El Monte, Calif.*

For more information circle **229** on inquiry card.

ILLUMINATOR FOR L-L GAGES

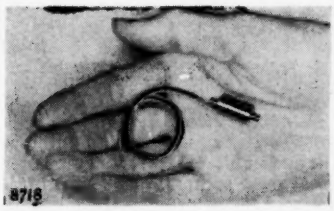
New "EPL-56 Illuminator" is claimed to give "up to three times the illumination and three times the bulb life." It lights up entire gage-glass length without glare spots or blinding areas; is easily mounted on back of transparent gages; is explosion-proof and UL approved. Available in single and double sections in various sizes.—*Jerguson Gage & Valve Co.*, 80 *Adams St., Burlington, Mass.*

For more information circle **230** on inquiry card.

FORCE

LOW-RANGE TORQUE PICKUPS

Two new low-range torque transmitters are added to maker's line of variable-permeance units. "Model TF-5-0.5" has full torque range of 0.5 lb-in and "Model TF-5-0.05" 0.05 lb-in. They operate without brushes and

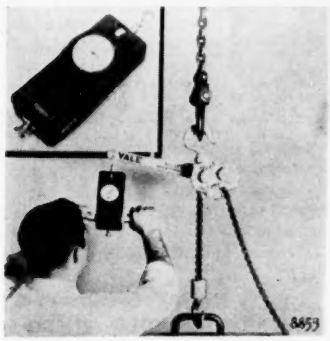


slip rings, with no contact between torque shaft and pickup housing. Sensitivity and linearity unaffected by shaft speed. Units are equally effective for measurements of static or dynamic torque.—*Crescent Engineering & Research Co., El Monte, Calif.*

For more information circle **231** on inquiry card.

MAX-READING FORCE GAGES

Four new mechanical force gages can hold maximum reading after load has been removed; are similar to mak-



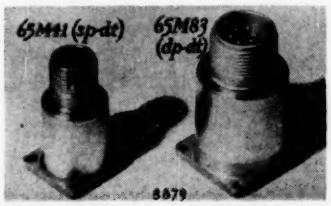
er's standard "Series D"; have maximum load capacities of 50, 100, 150 and 200 lb. A single control button selects desired operation; either to hold maximum reading or to follow all load fluctuations. Each gage has four interchangeable compression heads and an extension hook, all removable. —*Apparatus Div., Hunter Spring Co., Apparatus Div., Lansdale, Pa.*

For more information circle **232** on inquiry card.

DISPLACEMENT

POSITION SWITCH

New "Capswitch," developed for use in aircraft and guided missiles but adaptable to any type of control



where repeatability within 0.001" is desired, signals when a valve (or other device) has completed its closing or opening cycle. It is mechanically

Helicoid Gages

Acaloy Flanged Case

Helicoid gages set new standards of enduring accuracy, trouble-free service, and economy

Acaloy Flangeless Case

Phenol Turret Case

Acaloy Flush Case

Acaloy Square Flush Case

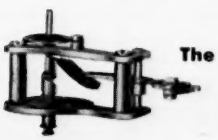
Industry has found in the HELICOID Gage, the most durable and efficient instrument ever devised to meet pressure-indicating requirements.

No Gears—No Teeth to Wear Out!
The exclusive HELICOID Movement is a simple, gearless cam-and-roller design with no teeth to wear out. It provides long and trouble-free service with a minimum of maintenance.

Sustained Accuracy—Longer Life
Because of advanced design, quality control in manufacture, and endless testing, HELICOID Gages produce more sensitive response to pressure changes. Their accuracy *endures*—even after millions of cycles.

Lowest Cost per Gage per year
These gearless gages go on performing day in and day out with little or no maintenance. This economy, together with long life, adds up to the fact that HELICOID Gages cost less per gage per year than any other gage you can buy.

Gages for vacuum and compound service. Pressure ranges up to 20,000 psi.



The Helicoid Movement

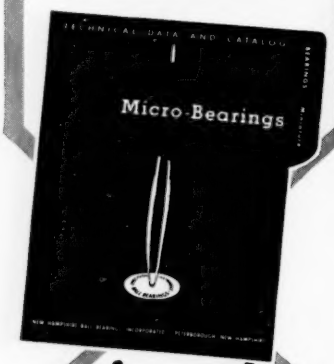
ACCO

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-B Connecticut Avenue • Bridgeport 2, Connecticut

For more information circle **73** on inquiry card.

FREE DESIGN HANDBOOK!



New!

72-PAGE TECHNICAL MANUAL AND CATALOG ON MICRO-BEARINGS

miniature ball bearings

If you work with miniature instrument-type ball bearings you'll find this new, authoritative publication a complete, handy source of engineering data and specification information.

HELPS SOLVE DESIGN PROBLEMS

Far more than an ordinary catalog— it contains a helpful survey of factors to consider in selecting and applying miniature ball bearings—plus 60 pages of engineering bulletins covering all the aspects of bearings important to designers . . .

Available types
Radial and axial play
Dynamic and static loads
Lubrication
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Sent FREE to Engineers, Draftsmen, and Purchasing Agents
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NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, N.H.

For more information circle **74** on inquiry card.

NEW INSTRUMENTS

actuated by a sealed plunger, which is depressed by valve stem or other member.—*Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn.*

For more information circle **233** on inquiry card.

DISPLACEMENT PICKUP

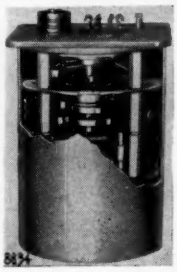
New "Model RP 04-0101," especially designed for high performance in severe environmental applications, has

a travel of 4.13"; provides complete flexibility in mounting and electrical characteristics. Resistance 30,000 ohms +10%; linearity 0.2%; power dissipation up to 2 w; withstands temperatures from −65°F to 275°F, vibration 10 *G* @ 10 to 1500 cps, and shock up to 60 *G*; service life 1,000,000 cycles.—*Humphrey Inc., 2805 Canon St., San Diego 6, Calif.*

For more information circle **234** on inquiry card.

TIME, SEQUENCE, SPEED, COUNTING

SMALL SEALED TIMER

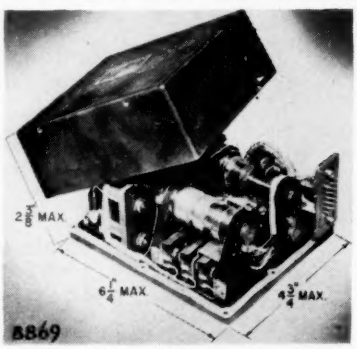


New "Type 825" hermetically-sealed time delay relay meets all environmental requirements for aircraft and ground installations; is available with one to six contacts and with time cycles from fractional seconds to multiple hours. Timer shown has provision for external timing adjustment. Synchronous motor drive for 60- and 400-cps applications; for dc, either a permanent-magnet or a governor-controlled motor.—*Eagle Signal Corp., Moline, Illinois.*

For more information circle **235** on inquiry card.

MULTIPLE SEQUENCE TIMER

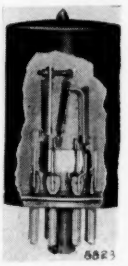
New "Type ST-9610-01" rapid-response multiple-contact sequence timer handles up to six separate timing



sequence operations simultaneously. Switches can be actuated by a magnetic clutch and cam arrangement which resets to zero on completion of timing cycle or in event of power failure. In addition to these clutch-actuated switches, timer contains five continuously-pulsating switches, one of which continuously operates in a closed position for 0.05±0.01 second and open for 0.45±0.04 second.—*John Oster Mfg. Co., Avionic Div., Racine, Wis.*

For more information circle **236** on inquiry card.

TIME DELAY RELAY

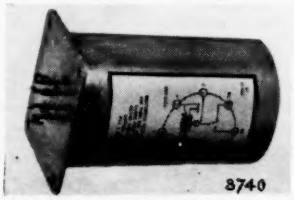


New "Thermal Memory Relay" bistable time delay relay with sp-dt snap action contacts is thermally operated: Each of two separate heaters transfers a movable arm from one contact to the other. Relay remains in either position until operated by the other heater circuit. Bimetal strips are perfectly matched, thereby compensating for ambient temperature variations. Operating time is factory preset for either 20 or 30 sec on both transfers.—*Curtiss-Wright Corp., Electronics Div., Carlstadt, N. J.*

For more information circle **237** on inquiry card.

15-30-SEC-CYCLE TIMER

New miniature (2 9/16" dia) motorized Time Delay Switch, accommodating up to 5 sp-dt switching functions,



has a timing accuracy of 5% of a total timing cycle under all conditions; meets environmental requirements of MIL-E-5272 and radio noise per MIL-I-6181B if desired. Normal delays 15 to 30 sec. At end of timing cycle, motor stops automatically with switch position maintained by clutch. Power interruptions during or after a timing cycle will result in automatic reset.—*Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.*

For more information circle **238** on inquiry card.

TACHOMETER GENERATOR

New Size 11 servomotor tachometer generator comprises a high-performance low-inertia ac servomotor directly coupled to an induction generator of drag cup type; is equipped with a precision gearhead; operates in am-

FREQUENCY STANDARDS

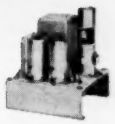
*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L



Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

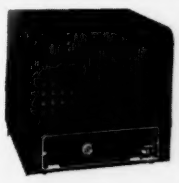
*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005



Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

Frequencies: 50 to 400 cycles (Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2007T
TRANSISTORIZED

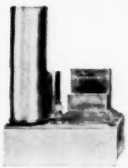
Size 1½" dia. x 4½" H. Wght. 7 ozs.*

Frequencies: 240 to 1000 cycles
Accuracies:—Same as 2003, above
Type 2007S—Silicon type
Input, 28V.
Output, Multitap, 75 to 100,000 ohms
*3½" in 2007S, 400 to 800 cycles.

FREQUENCY STANDARD
TYPE 2121A

Size
8¾" x 19" panel
Weight, 25 lbs.

Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)



FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C

Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.

Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.

ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies multi-vibrator type, 40-200 cy.
D—For low frequencies counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

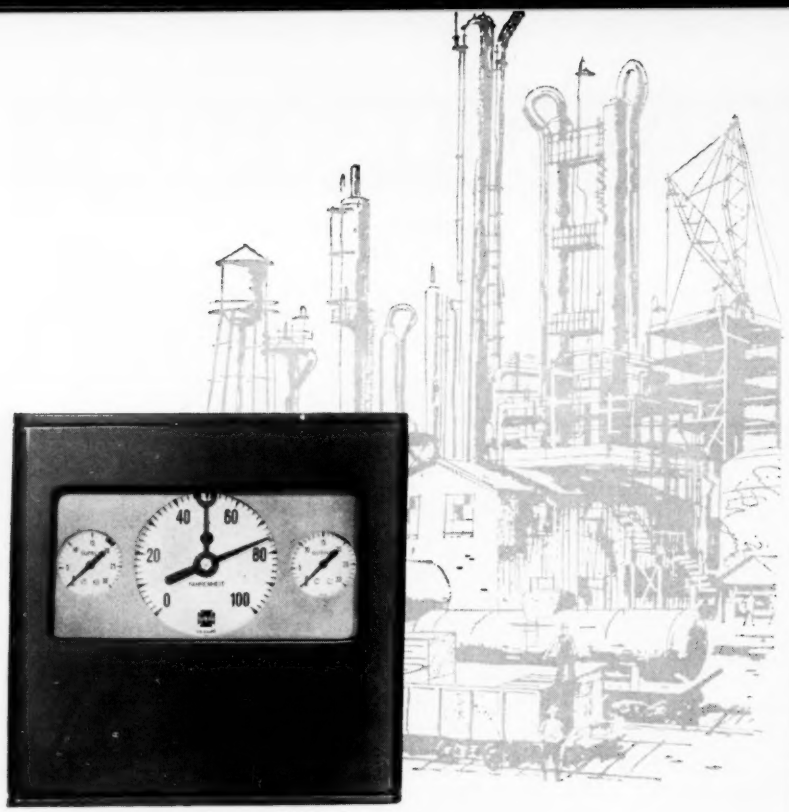
This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

WHEN REQUESTING INFORMATION PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

580 FIFTH AVENUE, NEW YORK 36, N. Y.

For more information circle **75** on inquiry card.



PATENTS APPLIED FOR

NEW USG Temperature Pilot

with automatic reset

Temperature, Reset and Expanded Ranges feature the enlarged U. S. Gauge line

The exclusive USG indicating, mercury-actuated temperature pilot is available in ranges from −40°F. to +1000°F.

Pressure and Temperature Pilots are available with or without automatic reset. When process conditions change, conversion kits make possible addition of automatic reset to existing installations.

With the new USG nested diaphragm pressure elements, vacuum and low pressure pilots never before available are now standard.

Only U. S. Gauge offers pressure pilots in ranges as low as 30 inches of water . . . as high as 10,000 pounds.

Write your valve supplier for complete details, or write us direct.

UNITED STATES GAUGE

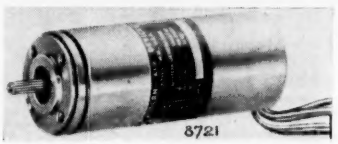
Division of American Machine and Metals, Inc.
Sellersville, Pa.

Home of the **SUPERGAUGE**

G 910.2

For more information circle **129** on inquiry card.

NEW INSTRUMENTS



bients up to 150°C; features low nulls (0.008 v rms in phase, 0.015 v rms quadrature and 0.019 v rms total null) and linearity of 0.5% at 3600 rpm; meets BuOrd MK-14 specs.—*Eastern Air Devices, Inc., 355 Central Ave. Dover, N. H.*

For more information circle **239** on inquiry card.

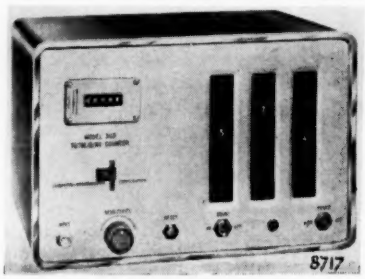
HAND TACHOMETER

New "Deumo 2" has a measuring range from 40 to 50,000 rpm in three speed ranges; accuracy 0.5%; unaffected by temperature changes or by magnetic fields; features handy push-button stop and unique switchgear for torque balance. Supplied in carrying case with several shaft tips.—*Epic Inc., 154 Nassau St., New York 38, N. Y.*

For more information circle **240** on inquiry card.

ELECTRONIC COUNTERS

New "300 Series Totalizing Counters" are direct-reading high-speed electronic counters especially designed

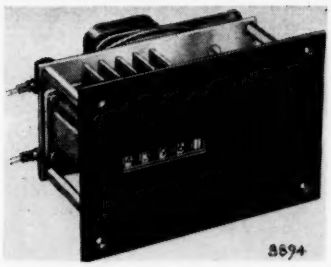


for industrial and special-purpose counting of any electrical, mechanical or optical events convertible into electrical pulses. Among features: two outputs (relay and pulse); max counts per second from 150 (Model 301A) to 100,000 (Model 304A); pulse pair resolution 5 usec; input requirements 0.05 v rms.—*Computer-Measurements Corp., 5528 Vineland Ave., North Hollywood, Calif.*

For more information circle **241** on inquiry card.

COUNTERS AND CONTROLLERS

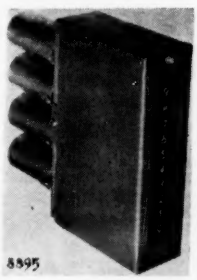
New "Electrical Data Readout Counters" perform multiple functions of direct indication, remote indication.



recording, and controlling. Either electrically or mechanically actuated and offering manual or electrical reset, new units automatically create specific contact closures for each reading visually displayed. Serial or parallel data transmission can be accomplished through use of sequence scanners or direct connections. Transmission can be continuous or intermittent with counter providing data storage. Advantage: compatibility of units with standard commercial equipment.—*Veeder-Root Inc., Hartford 2, Conn.*

For more information circle **242** on inquiry card.

ADD-SUBTRACT COUNTER

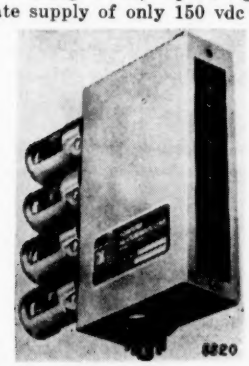


New "Add-Tractor" electronic decimal counter, believed to be "the only product of its kind on the market," can also be used for servo control, net weighing, digital position control, ratio control, subtractive mixing, frequency deviation measurement, random events difference counting, digital to analog conversion, computer arithmetic elements, etc. It can accept digital information serially as a unitary pulse train, or in parallel in binary coded decimal form.—*Victor Adding Machine Co., 3900 N. Rockwell St., Chicago 18, Ill.*

For more information circle **243** on inquiry card.

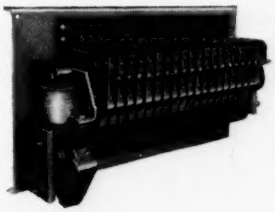
LOW POWER DECADE COUNTERS

New "100L Series Low Power Decade Counting Units," operating from a plate supply of only 150 vdc @ 7.5



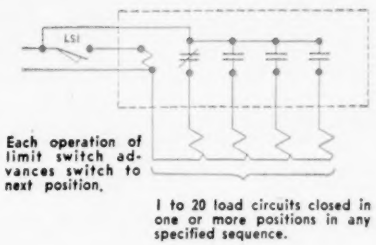
NEW EAGLE STEP SWITCH SIMPLIFIES CIRCUIT SEQUENCING

. . . for machine tools, presses, conveyors, processes

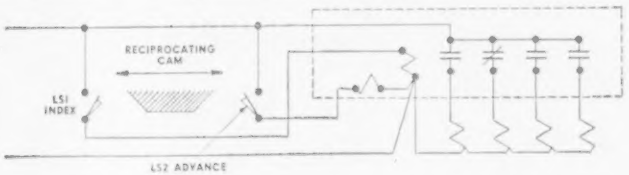


These 3 basic ideas are yours for simplified interlocking or sequencing of multiple load circuits. Any and all three will eliminate many other electrical components, and cut your initial cost.

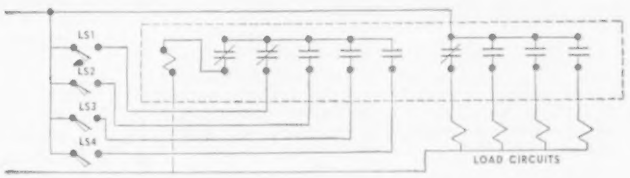
Operating load circuits in sequence: A limit switch on a machine or indexing device closes and opens upon each operation to advance the Eagle step switch. Or a timer may be used to operate each load circuit for a predetermined time.


LSI
Each operation of limit switch advances switch to next position.
1 to 20 load circuits closed in one or more positions in any specified sequence.

Interlock sequence: *Two limit switches* are operated alternately. This provides a safety feature. It insures that the movement of the machine has been completed before the Eagle step switch advances.



Interlock sequence with several limit switches: Each limit switch advances the Eagle step switch one position. Switches must operate in sequence or the step switch won't advance.



Send for new Eagle Bulletin 850. Simply write to Eagle Signal Corporation, Industrial Timers Division, Moline, Illinois, Dept. IA-357.

For more information circle **78** on inquiry card.

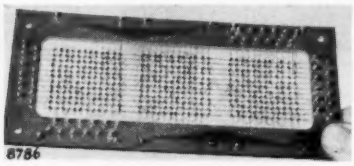
ma from 0 to over 100 kc, supplement "100 Series," provide models for pulse, analog or binary output; are designed to be physically and electrically interchangeable with most existing low-power decade counters; offer superior performance and reliability when used as replacements.—*Computer-Measurements Corp., 5528 Vineland Ave., N. Hollywood, Calif.*

For more information circle **244** on inquiry card.

COMPUTING and DATA PROCESSING

MAGNETIC MEMORY MATRIX

New memory is a three-dimensional type construction on a single plane. All respective X and Y lines are connected in series through each of three separate matrices, but memory makes available separate sense and inhibit lines for each of the three. This type of construction saves cost and space in installation of a matrix store. Example: a 144-word 15 digit-per-word storage system would require 15 twelve-by-twelve conventional matrices having 28 sets of interconnecting lines. Using the $12\times12\times3$ matrix shown, only 5 planes would be required, and only 8 sets of lines would have to be interconnected. New multiple matrix construction, being readily adapted to matrices of up to 16×16, will find wide use in small computer, buffer storage systems, and as a complete store in mock-ups. Multiple matrices are available in several different dimensions.—*Valor Electronic Components Co., 5808 Marilyn Ave., Culver City, Calif.*


8786

For more information circle **245** on inquiry card.

TAPE FOLDER

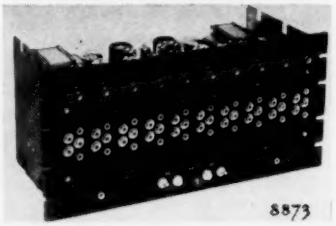
8720

New inexpensive "Model No. 1155 Tape File Folder", rapidly folds coded or punched tapes up to 100 ft long into convenient handling and filing sizes. Folding arm is properly arced to fold safely and allows easy removal of tapes ready for filing.—*Dresser Products, Inc., 152 Wheeler Ave., Providence 5, R. I.*

For more information circle **246** on inquiry card.

COMPUTING MANIFOLD

New self-powered "Model HKR Operational Manifold" is for use with maker's plug-in "Computing Modules"


8873

and indicators, recorders or oscilloscopes. (For readout convenience "GAP/R Electronic-Graph-Display" can be used.) "Model HKR" provides a rack-mounted array of ten "Model K2 Plug-in Operational Amplifiers" and a self-contained power supply on a single panel.—*George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass.*

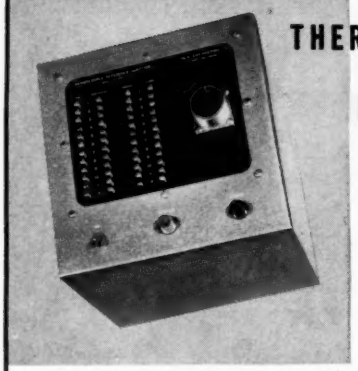
For more information circle **247** on inquiry card.

CONTINUOUS-LOOP MAG-TAPE RECORDER-REPRODUCER

New "Magneloops," said to represent "an entirely new concept in tape drive systems for continuous loop magnetic tape recorders," enable stepless control of tape speeds from 1⅞ to 15 ips with a frequency response of 50 to 15,000 cps at higher speed; have continuously-variable automatic equal-

PACE

THERMOCOUPLE REFERENCE JUNCTION



RJ SERIES THERMOCOUPLE REFERENCE JUNCTIONS operate from 115 volt line to provide thermostatically controlled temperature reference for multi-channel thermocouple systems. Reference Junction permits use of copper lead wire without inconvenience of ice-bath maintenance, and eliminates necessity for cold-junction compensation.

Features...

Temperature stability within ½°F, and uniformity within 0.1°F.
Control temperature adjustable.
Multi-wire junctions available for thermocouple choice in each channel.
Variety of thermocouple types, number of channels and input-output connections offered in standard models.

PACE *engineering company*

6914 Beck Avenue, North Hollywood, California • Phone POplar 5-0453

For more information circle **79** on inquiry card.

Who likes to keep a customer waiting? Not the men of Plummer & Kershaw at any rate. Unfortunately scheduling is easy but producing to the high quality standards that have made P & K respected, is another thing. Work done with skill and care is not work that can be produced quickly. As inevitable then as night follows day it is necessary to specify longer delivery dates—we feel sure you wouldn't want it otherwise.

TURN TO PLUMMER AND KERSHAW FOR—

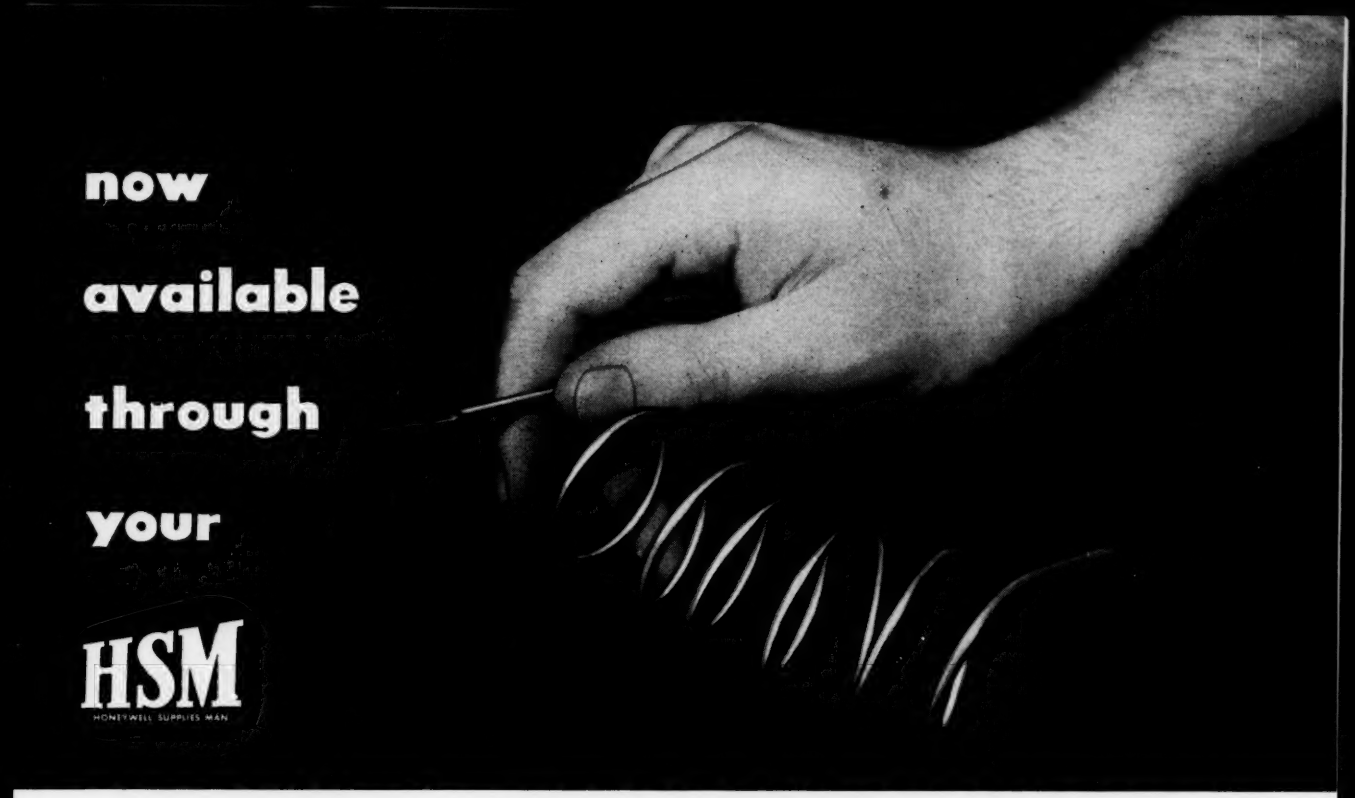
* Complete Optical Instruments made to Specifications.
* Design and Manufacture of Optical Systems using Glass, Crystal or other Transmission Media.
* Lenses and Prisms of Many Types.
* Test Glasses.

PLUMMER and KERSHAW

PRECISION OPTICS

2759 Frankford Ave., Philadelphia 34, Pa.

For more information circle **186** on inquiry card



Honeywell's New MEGOPAK thermocouple wire small diameter . . . flexible . . . for use to 1400 F.*

DESIGNED originally for atomic energy projects, this ceramic-insulated packed type thermocouple wire is now available to industry. *MEGOPAK* wire is the latest development in small-diameter thermocouples, with emphasis on durability and high accuracy. It consists of two wires, surrounded by pure magnesium oxide insulation and encased in a metal sheath. This construction insures high accuracy and long life.

MEGOPAK wire is available in *Chromel Alumel*** and iron-constantan calibrations. Both can be supplied in either 1/16" or 1/8" diameter. The 1/8" wire is available with *Inconel* sheathing only, while the 1/16" wire is supplied with *Inconel* or 304 stainless steel.

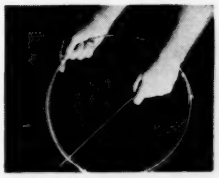
Lengths up to 25 feet have a minimum resistance of 2.5 megohms at 500 V dc at room temperature, when checked wire to wire or wire to sheath. The wire is flexible enough to be bent around twice its diameter . . . versatile enough to serve in a broad range of applications . . . rugged enough to withstand severe mechanical abuse. Accuracy meets the recommended tolerances of the Instrument Society of America.

MEGOPAK wire is one of the many special pyrometer supplies available with personalized service from your HSM (Honeywell Supplies Man). For complete details, call the HSM at your nearby Honeywell branch . . . as near as your phone. Or write for Specification S001-4.

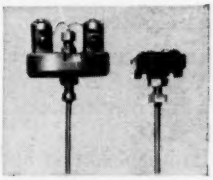
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Penna.—in Canada, Toronto 17, Ontario.

**Trademark Minneapolis-Honeywell Regulator Co.*
***Trademark registered, Hoskins Manufacturing Co.*

ORDER *MEGOPAK* WIRE OR ASSEMBLIES

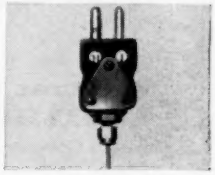


MEGOPAK *wire is available in standard lengths from 6 to 25 feet in 6-inch increments.*



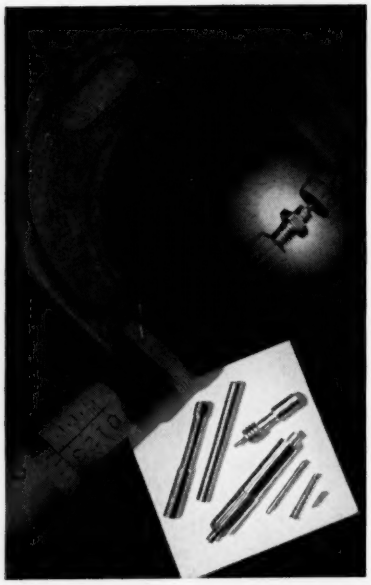
Assemblies with terminal blocks are used for replacement units or where a terminal head can't be supported.

Assembly with terminal blocks and head. It's ready to use, with attachment of extension wires.



Assembly with quick-connect plug that need only be inserted in jack for use.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls



If production "pivots" on costs

MODERN, standardized production methods developed by Welton V. Johnson mean better, lower cost instrument pivots, shafts and other precision miniature parts for you.

Quality production methods assure you the finest pivots, shafts, staffs and other miniature special steel parts, all heat treated for maximum hardness and polished to a metallographic finish. Sizes up to $\frac{3}{16}$" diameter.

Write today for complete information on Johnson pivots, samples or specific quotations.

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precision miniature parts

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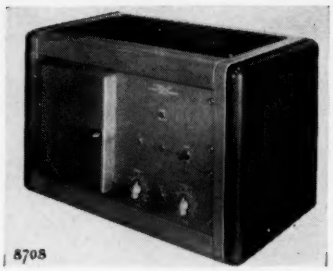
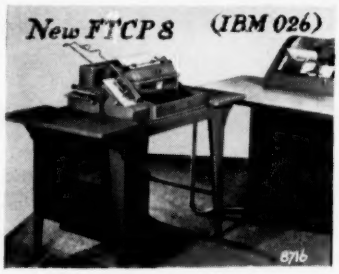


ization and amplitude compensation. Recorders, reproducers or recorders-reproducers available in single- dual-, and triple-channel models. Applications include study of radiations, enemy gun location, geophysical exploration, as well as automatic sequence control of servomechanisms, etc.—*Amplifier Corp. of America*, 398 *Broadway, New York* 13, *N. Y.*

For more information circle **248** on inquiry card.

AUTOMATIC WRITING MACHINE AND TAPE & CARD PUNCH

New "Model FTCP-8 Flexowriter Tape and Card Punch" can produce any style of typed document, from

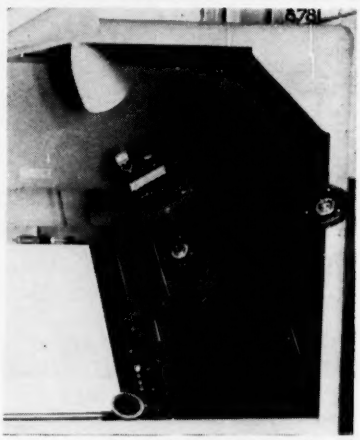


manual to automatic typing, and simultaneously create punched paper tape and tabulating cards; minimizes need for clerical help, tabulating card converters, key punches and verifiers; is cable-connected to either an "024" or "026" IBM card punch. Among features: alphabetic, numeric and special characters are punched directly in tabulating cards, whether operation is manual or from tape or edge punched cards.—*Commercial Controls Corp., Subs. Friden Calculating Machine Co.*, 1 *Leighton Ave., Rochester* 2, *N. Y.*

For more information circle **249** on inquiry card.

FILM-DATA PROCESSOR

New "Aero Film Mechanism" for rapid measurement and digitizing of *X* and *Y* coordinates from film as



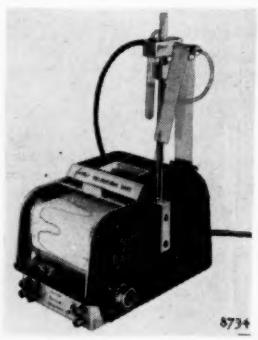
wide as 9.5" eliminates slow and tedious comparator measurements on wide-film records of missile trackings, bomb drops, and interceptions; features easy loading of film; is used in conjunction with "Telereadex Type 29A" to project any selected 2" square area of film with magnifications of either 10× or 20× to measure, by means of crosswires, distances on a projected image, and to permit zeroing at any spot on projected image. —*Telecomputing Corp.*, 16217 *Lindbergh St., Van Nuys, Calif.*

For more information circle **250** on inquiry card.

LABORATORY EQUIPMENT

CHROMATOGRAPH SCANNER

New "Automatic Radioactive Chromatograph Scanner" graphically presents the activity distribution along a paper chromatogram tagged with low-energy beta-emitting isotopes; employs a small flow counter with low background; can accommodate chromatograms up to 3" W and 60" L; is the only scanner that can be operated without window, thereby considerably increasing its sensitivity for C-14, S-35, H-3 etc. Design facilitates decontamination of all parts in contact with chromatogram.—*Forro Scientific Co.*, 833 *Lincoln St., Evanston, Ill.*

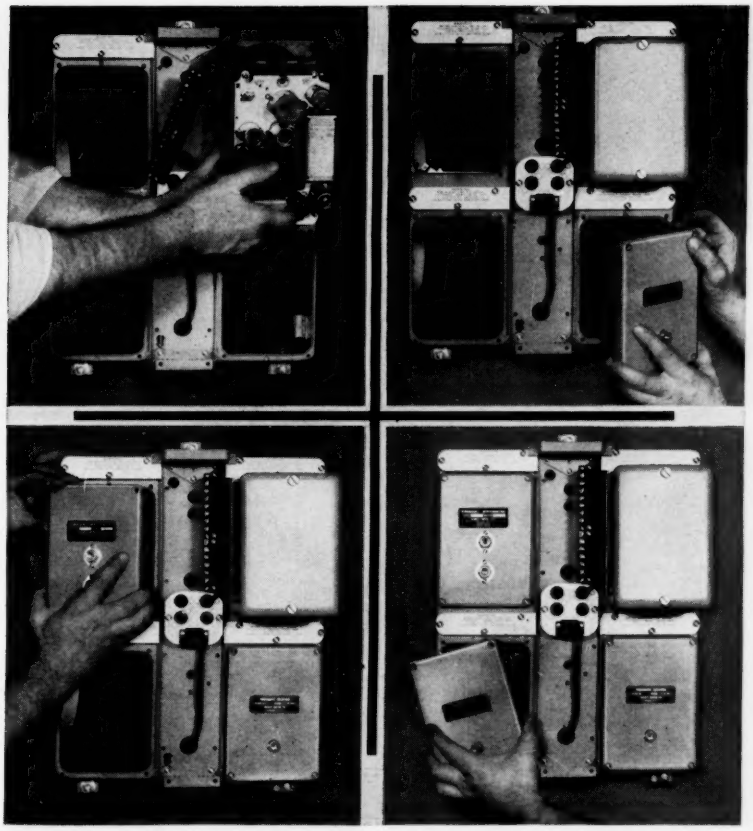


For more information circle **251** on inquiry card.

HEAVY DUTY BATHS

New Heavy Duty Baths available in five sizes have longer temperature range: 30°C to 125°C, controlled within 0.5C°, for operations where exact temperature control to and above H_2O

CUSTOM BUILD your own Bailey Recorder



These four views of the back of a Bailey Recorder show how four plug-in units may be added as needed to meet almost any recorder application.

The freedom and flexibility of "do-it-yourself" instrumentation is yours in the Bailey Recorder. A variety of plug-in units make it possible to record, control, and retransmit any variable that can be converted to a pneumatic or electric signal.

The basic plug-in units are the Bailey a-c and d-c Electronic Receivers and Pneumatic Receivers. Any four of these may be used in one recorder, intermixed in any way, to provide four continuous records on one chart.

For automatic control, other plug-in units are available.

For square root extraction or linear integration, there are two plug-in variations of the Bailey Integrator.

When you want a pneumatic signal that varies according to a pre-set pattern plug in a Bailey Program Controller.

Periodic running time of a condition or process is recorded on the chart when a Bailey Running Time Recorder is used.

These and other plug-in units are described in Product Specification E12-5. Some companies stock Bailey Recorder cases and assorted plug-in units. As instrumentation and control needs arise they build up the kind of recorder-controller required, using the proper plug-in units from stock. Unmatched versatility such as this means lower instrumentation costs.

For the complete story of how easily you can custom build this recorder to your needs, see your Bailey Engineer. G43-1

BAILEY METERS

Instruments and controls for power and process

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For more information circle **81** on inquiry card.

The
Curtiss-Wright
"SNAPPER"

NEW CONCEPT... ADVANCED DESIGN
IN THERMAL TIME DELAY RELAYS

- Eliminates chatter with **snap action**
- Single-pole, double throw contacts
- Wide ambient range (−65°C +100°C)
- For military, commercial and industrial applications
- Metal envelope (7 or 9 pin) miniature or (8 pin) octal
- Glass envelope in 9 pin miniature
- Preset time delays in metal from 3 to 90 seconds, glass from 5 to 60 seconds

Write to Thermal Devices Department for latest data sheets

ELECTRONICS DIVISION
CURTISS-WRIGHT
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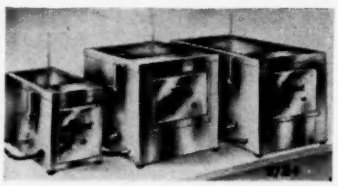
For more information circle **82** on inquiry card.

NEW INSTRUMENTS

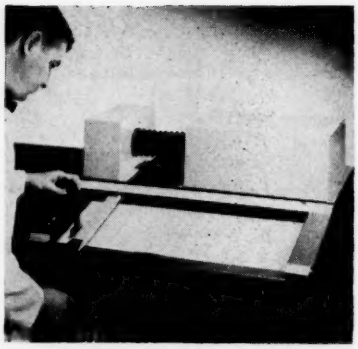


boiling-point is important. Features include conveniently located controls protected against accidental change of setting with Visa-glass; double-wall stainless steel construction with 1" of insulation between walls; built-in accessories at no additional cost.—*Electric Hotpack Co., 5029 Cottman St., Philadelphia 35, Pa.*

For more information circle **252** on inquiry card.

RECORDING INFRARED SPECTROPHOTOMETER

New automatic "IR-6" records linearly in transmittance and wavelength from 2 to 16 microns; offers "excellent accuracy and resolution"



for qualitative and quantitative analyses; sells for "about one-third the price of the larger infrared spectrophotometers." Operation is simple: pushing a button will start a 16-minute scan through entire 2-16-u spectrum. Except for START and STOP buttons and selector switch, the only other controls are the customary zero and 100% adjust knobs.—*Beckman Instruments, Scientific Instruments Div., Fullerton, Calif.*

For more information circle **253** on inquiry card.

DIMENSIONAL INSPECTION, GAGING

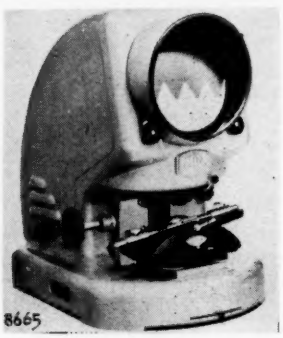
THREAD-CHECK GAGE

New gage can check and indicate pitch diameters of any threaded part having external screw threads up to 1½" dia and of any specified pitch; requires no special wires or attachments; can be quickly and simply operated mechanically to obtain pitch diameter readings from 0" upward on a large dial graduated in 0.0001". It can be adapted for use with maker's "Precisionaire" and "Plunjet" or with "Accutron Amplifier" and "Electro-jet."—*Division 710, The Sheffield Corp., Dayton 1, Ohio.*

For more information circle **254** on inquiry card.

OPTICAL COMPARATOR

New "TP200" 8" optical comparator (made by Leitz) features vertical light beam (exception rather than rule in optical comparators in its price class). Advantage is that workpiece is simply laid on horizontal stage and that measurements in both dimensions are obtained in natural motions: from left to right or front to rear respectively. Some other features: quick-indexing objective turret for 10X, 20X and 50X magnification, retractable vertical illuminator for reflected images in all 3 magnifications, selective filters for increase of contrast in transmitted as well as reflected light,

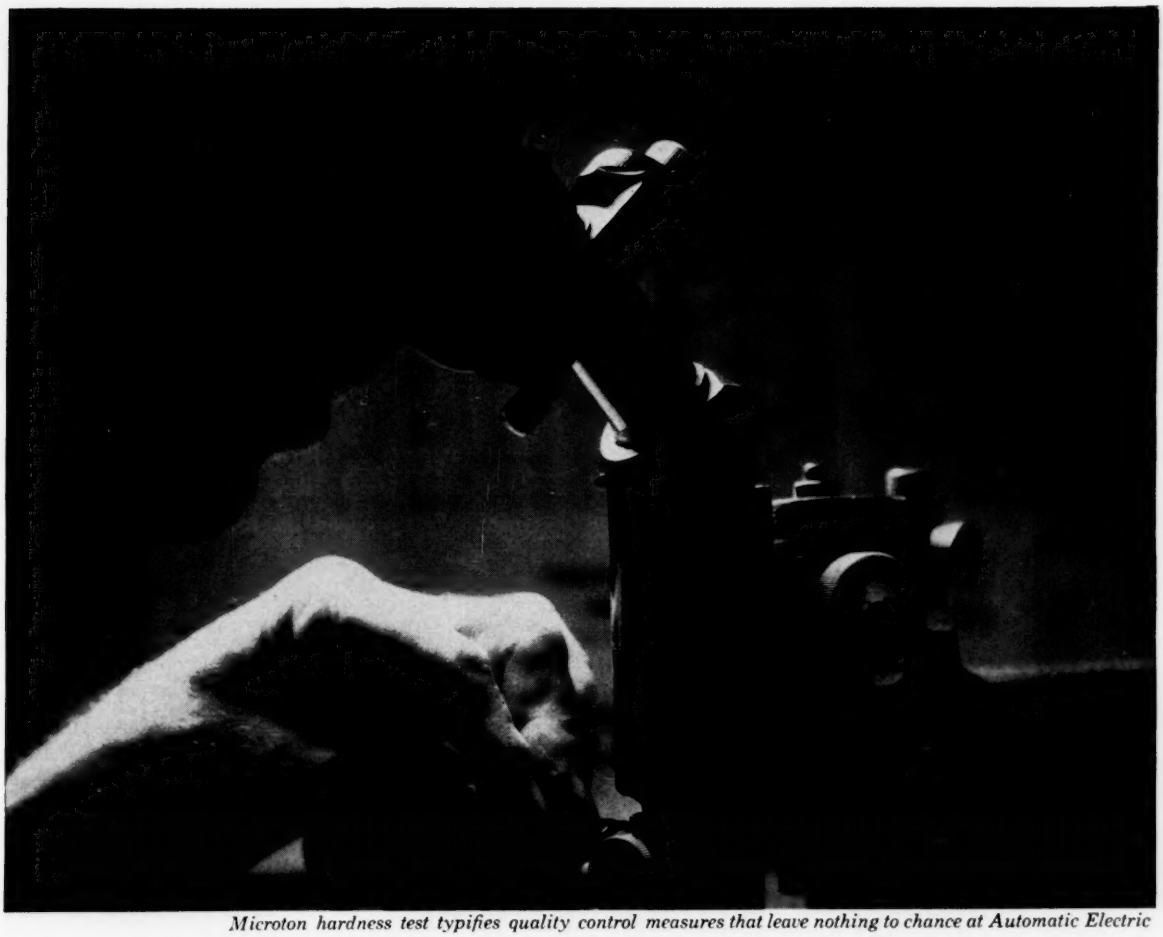


rotating circular screen for angular measurements.—*Opto-Metric Tools, Inc., 137 Varick St., New York 13, N. Y.*

For more information circle **255** on inquiry card.

GONIOMETER

New Goniometer for production and inspection departments features a precision machine-engraved, 4½" protractor which, by means of a vernier,



Microton hardness test typifies quality control measures that leave nothing to chance at Automatic Electric

STANDARDS THAT DETERMINE RELAY QUALITY

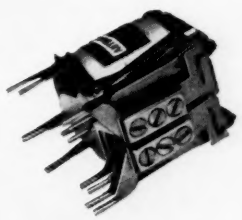
the ideal relay iron

Only soft, pure iron assures proper release, even after millions of operations.

In service, many relays get progressively slower to release, until finally the armature hangs up permanently. Excessively "hard" magnetic relay iron often is to blame. But in all Automatic Electric relays, the magnetic iron is so soft and pure that it saturates quickly, yet the flux dies out instantly. Even after millions of operations!

This improved relay iron is made and rolled to our own exacting specifications. Chemical analysis then makes certain that no magnetic capabilities have been lost. Annealing is rigidly controlled, and grain size and temper carefully checked. Elongation, hardness, permeability, and density tests further safeguard this pampered material. Result: not the *ideal* relay iron, but *the most nearly perfect iron available.*

This is no isolated example. Exhaustive tests prove that all our raw material is equally fine. It's one of the many reasons why Automatic Electric relays enjoy far longer life.



Series SQPC Relay for printed circuitry applications. *Write today for Bulletin RH-9. Automatic Electric Sales Corporation, Chicago 7.* In Canada: *Automatic Electric Sales (Canada) Ltd., Toronto.* Offices in principal cities.

AUTOMATIC ELECTRIC

Originators of the dial telephone • Pioneers in automatic control

GENERAL SYSTEM

For more information circle **83** on inquiry card.

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For more information circle **84** on inquiry card.

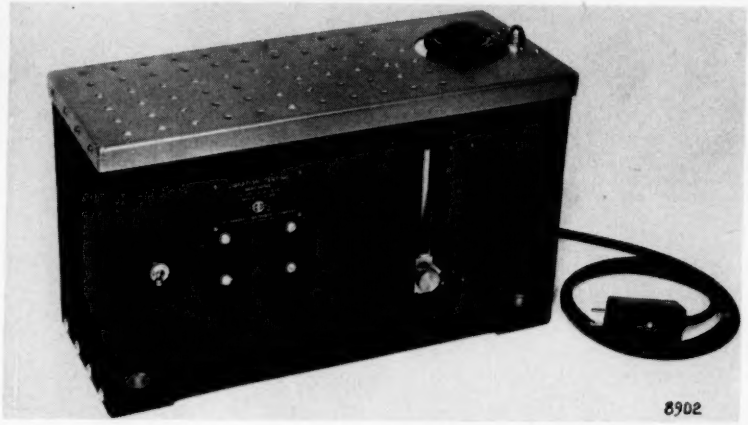
NEW INSTRUMENTS

can be read to one minute of arc. (accuracy of graduation ±15 seconds). Angle head turns in a tapered steel bearing as in astronomical and surveying instruments. Goniometer will accommodate six different diameters of locating boss in range 0.750" to 2.875". All the standard size synchro and pot mounting diameters fit without any alteration. Adaptors are available to accommodate any nonstandard diameters.—*Electro-Mec Lab., Inc.,* 47-51 33*rd St., Long Island City* 1, *N. Y.*

For more information circle **256** on inquiry card.

MECHANICAL TESTING

VIBRATION TESTING MACHINE

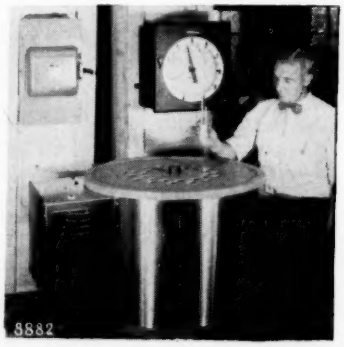


New "Model 14-28," though inexpensive, features true sinoidal motion positively imparted to rigid table mounted on unique spring flexure system; amplitude infinitely variable (0-0.08" double) and frequency infinitely variable (10-55 cps) while machine is running; 5-lb max test load.—*The Ahrendt Instrument Co., College Park, Md.*

For more information circle **257** on inquiry card.

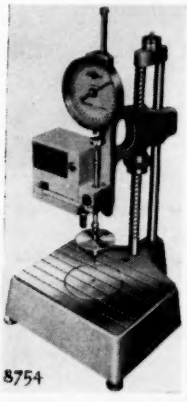
ELASTOMER AGING TESTER

New "Model LGH Metal Heatbath" is a tester for aging of elastomers at temperatures up to 1,000°F. Specimens are tested in individual isolated compartments in an electrically heated stainless steel block. Metal bath construction prevents contamination due to "exchange" between specimens. Exchange migration, if permitted, could reverse lab evaluation and completely upset performance in actual use. Desired temperatures are said to be maintained "within unbelievable tolerances."—*Scott Testers, Inc.,* 45 *Blackstone St., Providence, R. I.*



For more information circle **258** on inquiry card.

PENETROMETER



New model of maker's Penetrometer has built-in automatic electric timer featuring a preset 5-sec cycle cam, with reset switch for zero start. This timer prevents operator error in timing and is especially desirable when testing light greases with micro and semi-micro cones. Other features: 63 mm penetration suitable for use with the new Standard Oil of Indiana magnesium cone; dual upright guide posts; quick removable plunger (about 2 sec); single knob control for head, etc.—*Labline, Inc.,* 3070-82 *W. Grand Ave., Chicago* 22, *Ill.*

For more information circle **259** on inquiry card.

PAINT HARDNESS TESTER

New "ICI Automatic Sward Hardness Rocker," for measuring hardness of painted surfaces, maximizes ac-

ROBERT S. CHERNOFF

Graduated from M. I. T., B. S. in E. E. 1949, and joined Bell immediately as Test Engineer on Rocket Instrumentation. A year later he was appointed engineer in charge of the Instrumentation Laboratory and in 1953, became Group Engineer of Standards and Calibration. After two years from 1954 to 1956 as a Test Engineer in the Army, he returned to Bell as a Group Engineer, a position he now holds in the new Research Division.

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Professional progress comparable to Robert Chernoff's is typical, rather than unusual, at Bell Aircraft. The new Research Division, in particular, offers the broadest possible opportunities for creative talents in many fields thanks to the exceptionally wide diversity of Bell's activities. You'll never be held back by a lack of projects or bored by their narrow scope in this fast moving, progressive organization.

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- Digital Computer Development Engrs.
- Dynamic Engineers
- Electronic Engineers
- Electronic Standards Engineers
- Engineering Computers
- Environmental Specialists
- Field Test Engineers
- Flight Test Engineers
- Flight Test Programmers
- Fuel Injection Specialists
- Gear Designers
- Guidance Engineers
- Gyro Specialists
- Heat Transfer Engineers
- Hydraulic Engineers
- IBM Programmers
- Instrumentation Specialists
- Laboratory Test Engineers
- Magnetic Amplifier Specialists
- Mathematical Analysts
- Mechanical Engineers
- Microwave Engineers
- Miniturization Engineers
- Operations Analysts
- Physicists
- Power Plant Designers
- Pressure Vessel Designers
- Project Engineers
- Publication Engineers
- Radar Systems Engineers
- Rocket Test Engineers
- Servo Systems Engineers
- Servo Valve Engineers
- Statisticians
- Stress Engineers
- Structures Engineers
- Specification Writers
- Technical Writers
- Test Equipment Engineers
- Transformer Design Specialists
- Transistor Application Engineers
- Thermodynamic Engineers
- Telemetering Engineers
- Turbine Pump Designers
- Vibration & Flutter Analysts
- Weapons Systems Engineers
- Wave Guide Development Engineers
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1500 VOLT

single junction

welded case

SILICON

RECTIFIERS

from

Texas Instruments

You can now obtain maximum rectifier miniaturization along with nearly *double* the operating voltage previously obtainable from silicon rectifiers – with new TI *single element* grown junction silicon rectifiers. This two-fold advance – single element construction plus 1500-volt operating voltage – results in immediate extension of design limits in guided missile and other military applications. Also, these welded case rectifiers are ideal for use in series in cathode ray tube power supplies and similar high voltage circuits.

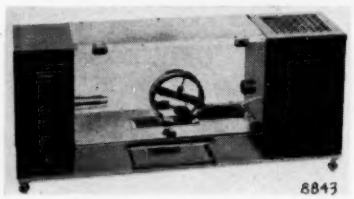
TI miniaturized silicon rectifiers feature forward current ratings to 125 ma and operate stably to 150°C. They require no filament power . . . no warm-up time. Five production types give you a choice of axial and stud half-wave types in welded case and full-wave plug-in model.

Write today for complete information

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

For more information circle **85** on inquiry card.

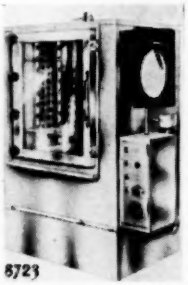
NEW INSTRUMENTS



curacy by eliminating human errors and other variables that distort test results: it automatically counts number of times (in a given interval) that a pendulum-like rocker oscillates over surface being tested; the harder it is, the more oscillations. Count is made by photocell and displayed on a four-digit register. 100 readings on new instrument had a mean square deviation better than 0.1% of average, compared to 5% with visual counting. —*Gardner Lab., Inc., Bethesda* 14, *Md.*

For more information circle **260** on inquiry card.

TESTING OVEN

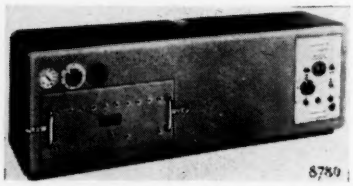


New "Model 8091," with 24" × 20" × 30" chamber, features continuous adjustment of both temperature and humidity: temperature from room to 100°C controlled within 0.5 C°, and humidity from 20% to 100% controlled within 5% RH, by means of a two-system recorder-controller. Humidity is introduced by combination of atomization and vaporization of temperature-conditioned water: no product condensation.—*Electric Hotpack Co.*, 5029 *Cottman St., Philadelphia* 35, *Pa.*

For more information circle **261** on inquiry card.

TEMPERATURE TEST CHAMBER

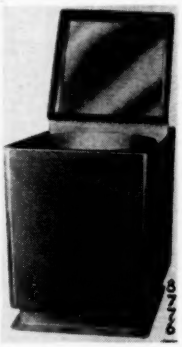
New "Model TC-4" chamber for testing of products at ambient temperatures between −65°F and 600°F



has 600 cu in of working space. Additional interchangeable test trays permit continuous operation and eliminate loading delays; are interchangeable with those of "Model TC-2" test chamber, within certain temperature limitation. Each test tray is provided with fifteen ⅜" dia openings for electrical or mechanical connections. Anticipator-type thermostat holds temperature fluctuations within 4 F°.—*Statham Development Corp.*, 12411 *West Olympic Blvd, Los Angeles* 64, *Calif.*

For more information circle **262** on inquiry card.

ROTARY ACCELERATOR



New small "Model C-1-A" rotary accelerator for calibrating and testing small assemblies and for calibrating accelerometers, can subject objects weighing up to 3 lb each to accelerations up to 250 *G*. Easily-removed 20" dia aluminum alloy rotating table has accurately-spaced circular graduations ¼" apart and groups of tapped holes for mounting as many as four test objects and balance weights. Objects as large as a 5" cube can be accommodated. Tachometer indicates speed; for extremely precise speed measurement an auxiliary magnetic pickup is used with external measuring equipment. With controls centralized, little experience or training is required to operate machine.—*Schaevitz Machine Works, Camden, N. J.*

For more information circle **263** on inquiry card.

ELECTRICAL TESTING

PULSE-HEIGHT ANALYZER

New "Model N-302" combines a stable non-overload pulse amplifier and a precision single-channel pulse height analyzer on one chassis for scintillation spectroscopy, single-component monitoring and proportional counter pulse analysis. Amplifier employs delay-line clipping and long-tailed pair stages with feedback, has good stability, short rise-time, and excellent overload characteristics (to 10,000%).—*Hamner Electronics Co., Inc., P. O. Box* 531, *Princeton, N. J.*

For more information circle **264** on inquiry card.

SYNCHRO TESTER

New "Model 100 Transformation Ratio Meter" is an rms-reading voltmeter for indicating voltages of synchros and synchro systems rapidly and simply with higher accuracy than

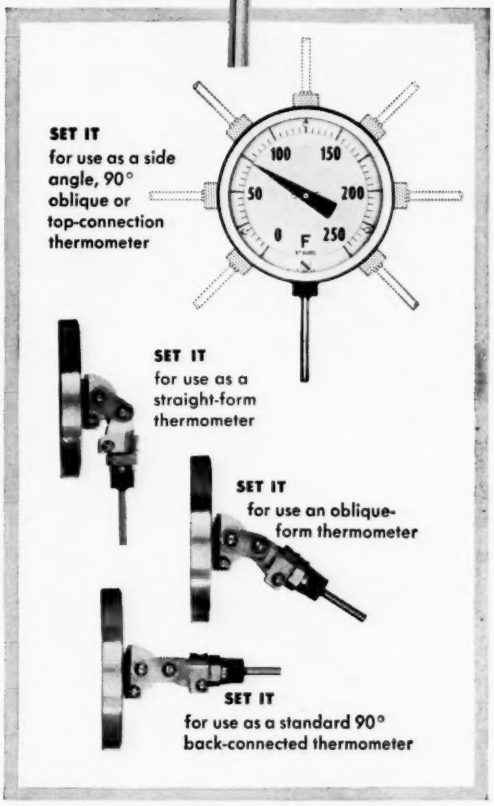
"Every Angle" Design Maxivision® Accuracy Bi-Metal Actuation

Now... all 3 in one 'American' Thermometer

Only this new American Thermometer* gives you the three features most demanded in a dial thermometer. The "Every Angle" design allows you to install this thermometer *anywhere* . . . then angle it in the direction that provides easiest reading. The anti-parallax Maxivision dial guarantees the surest, sharpest, easiest reading. Graduations are carried on a raised ring, set close to the cover glass, with an index-type, functional pointer set at the same level. The result – no perspective effect – parallax error practically eliminated. Finally, bi-metal actuation insures high sensitivity, economy, and surety of operation.

Install the new American "Every Angle" Bi-Metal Dial Thermometer anywhere – inside or out. Its climate-proof case defies any weather condition. The full use of these thermometers in any process plant makes possible temperature readings with the same ease and facility of those of a pressure gauge. Write today for complete information. Ask for Bulletin 148.

*Pat. App. For



SPECIFICATIONS

5-Inch Type 5-6060 American "Every Angle" Bi-Metal Dial Thermometer

Temperature Ranges: From minus 80° to plus 1000° F. Accuracy within 1% of range. *Dial Size:* 5". Scale approximately 10½" long. *Bi-Metal Coil:* Low mass, with single helix close to inside wall of stem assures high sensitivity. Silicone fluid dampens vibration, accelerates transfer, speeds response. *Case:* Stainless steel. *Bezel:* Threaded to case. *Front:* Clear, extra-heavy glass set in channeled gasket to seal case. *Pointer:* Functional type, adjustable from front. *Stem:* Lengths – 4" to 24", 18-8 stainless steel. All joints welded. *Connection:* Fixed, ½" NPT. *Separable Sockets:* Available in all materials and sizes normally required.

PHONE your Industrial Supply Distributor for experienced attention to your needs. He is always ready to help you ward off costly shut-downs through fast delivery from local stocks.

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A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

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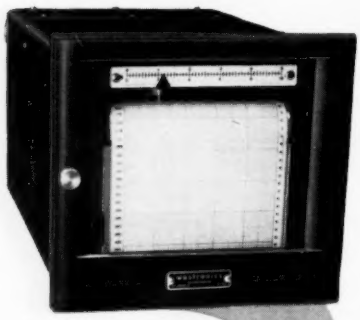
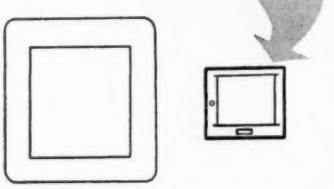
For more information circle **86** on inquiry card.

MINIATURE RECORDING POTENTIOMETER

This revolutionary recorder saves you two ways . . . fits in a small space (only 9⅜ inches wide and 8½ inches tall) and costs less.



Model 2705



COMPARE THE SIZE

SPECIFICATIONS

- Null balance
- Pen speed: 1 second
- .5% accuracy
- TC or MV calibration (5MV to 100MV)
- Automatic continuous standardization
- Max source impedance 1000 ohms per MV of span
- .14% sensitivity

OPTIONAL FEATURES

- 3 speed chart drive transmission
- 1 to 4 SPDT adjustable control switches
- Reference junction compensation
- Selsyn motor chart drive
- Transmitting slidewire
- Event marking margin pens

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For more information circle **87** on inquiry card.

NEW INSTRUMENTS

8778

obtainable by more conventional instruments. Indication is directly in percent deviation of transformation ratio of synchro from ideal ratio. Nominal input voltage 57.3, 78, 90, 105, 115; frequency 50 to 1,000 cps; impedance 10,000 ohm/volt.—*Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A, Richmond, Calif.*

For more information circle **265** on inquiry card.

TRANSISTOR TESTER

8709

New portable transistorized "Model KT-1" has been designed specifically for measurement of beta, h_{11} *and* I_{CO}; is completely self-contained with its own 1-kc oscillator and mercury-cell power supply. (Battery life about 1000 hr). Printed circuitry, used throughout, enhances portability and ease of maintenance. Tester enables adjustment in direct-reading calibrations to compensate for temperature variations. An external jack permits collector wave-form observation.—*Baird-Atomic, Inc., 33 University Road, Cambridge 38, Mass.*

For more information circle **266** on inquiry card.

PULSE GENERATOR

New "Model 502," completely transistorized and using printed circuitry, is self-powered by a 22½-v "B" battery (useful life of 450 hr), provides pulse length from 0.5 to 3 usec in

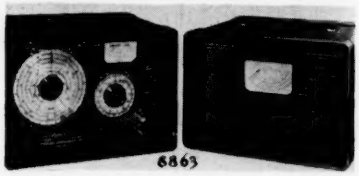
8719

three steps with a 20-v peak into an 800-ohm load. Positive or negative pulses continuously variable from zero to full amplitude. Rep rate on internal sync 50 to 5,000 pps, on external sync 0 to 5,000 pps. Internal impedance 100 ohms or less on either pulse polarity. —*Cubic Corp., 5575 Kearny Villa Rd., San Diego 11, Calif.*

For more information circle **267** on inquiry card.

MOBILE RADIO TRANSCEIVER TEST SET

New portable test set for mobile radio comprises "Model 1064" high-stability FM signal generator cover-



8863

ing 30, 160 and 450 Mc bands; unique system of crystal calibration eliminates frequency errors. Twin unit, "Model 1065," measures RF power from 1 to 100 watts (with external attenuator), AF power from 20 uw to 3 w, FM deviation from 0 to 15 kc, dc volts from 0.2 to 1000 and direct current from 1 ua to 1 a.—*Marconi Instruments, 44 New St., New York 4, N. Y.*

For more information circle **268** on inquiry card.

FREQUENCY METER

New "Type 5890-A" crystal-controlled frequency meter capable of servicing multiple transmitter instal-

8828

lations operating on one to twenty channels in mobile radio communications systems features transistorized circuitry; can be utilized with any transmitter operating within complete land-mobile services' frequency bands: 25 Mc to 470 Mc.—*Mobile Communications Sales Dept., Allen B. Du Mont Labs, Inc., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **269** on inquiry card.

SONIC ANALYZER

New "Sonic Analyzer LP-1a," improved model of "LP-1," provides a logarithmic sweep range of 40-20000

Circle **88** on inquiry card. ⟶

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nothing works if the connector fails!

Wherever you go in an automatic control system you find infinite care taken to provide fast, accurate and trouble-free operation in every element... whether it be gears, relays, solenoids, or basic electronic components.

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G. B. SHAW, *Vice President—Procurement*
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Thermostatic DELAY RELAYS

2 to 180 Seconds

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- *SPST only* — normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from −55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive!*

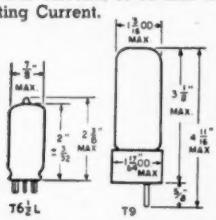
TYPES: Standard Radio Octal, and 9-Pin Miniature

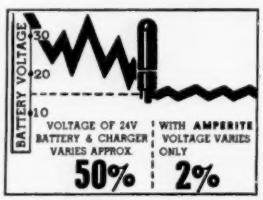
PROBLEM? Send for Bulletin No. TR-81

Also — **Amperite Differential Relays:** Used for *automatic overload, under-voltage* or *under-current protection.*

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.) ... For currents of 60 ma. to 5 amps. Operate on A.C., D.C., Pulsating Current.





T9 BULB

Hermetically sealed, they are not affected by changes in altitude, ambient temperature (−55° to +90° C.), or humidity ... Rugged, light, compact, most inexpensive.

Write for 4-page Technical Bulletin No. AB-51

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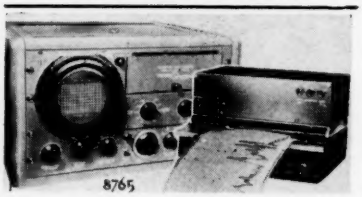
Individual inspection and double-checking assures top quality of **Amperite** Products.

For more information circle **89** on inquiry card.

NEW INSTRUMENTS


8765

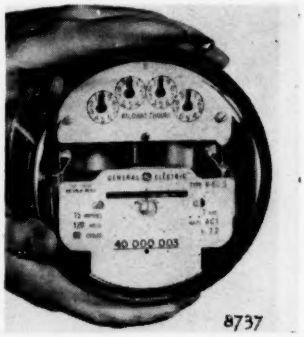
cps and extends linear sweep ranges of "LP-1" by 200, 1,000 and 5,000 cps. A companion recorder is also available with new "LP-1a" for charting purposes. Tuning controls allow selection of narrowed bands within frequency range for detailed analysis. Scan speed is 1 second, automatically slowed to 10 sec, 2 min, or 16 min for recording. Resolution of better than 25 cps over a sweepwidth of 200 cps at any point in spectrum (or 40-20,000 frequency range) is unique.—*Panoramic Radio Products, Inc.,* 10 *S. 2nd Ave., Mount Vernon, N. Y.*

For more information circle **270** on inquiry card.

ELECTRICAL & ELECTRONIC INSTRUMENTS

WATTHOUR METERS

New "V-60 family" polyphase watthour meters feature extended range, magnetic suspension, and surge pro-



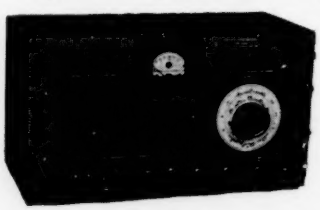
8737

tection. First available is "V-62" network meter, supplied in Class 100 and Class 200 ratings. Its extended range obviates meter replacement as polyphase loads grow. Maximum temperature rise is 55C° at 666% of rated current.—*Meter Dept., General Electric Co., Somersworth, N. H.*

For more information circle **271** on inquiry card.

PRECISION PHASE DETECTOR

New "Type 205A" detects time delay or phase angle with error less than 1% or 0.1° (whichever is larg-



precision

PRESSURE REGULATORS

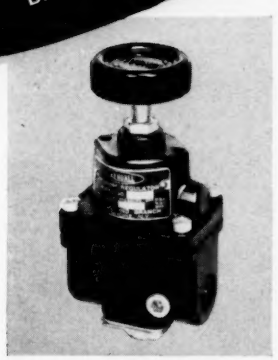
14 models to meet almost all industrial needs

Send for catalog

Now available from the Stratos Industrial Products Branch are two complementary lines of pneumatic pressure regulating valves.

The pilot-operated GOVERNAIRE: very high flows are regulated by small signals in these self-contained, pilot operated models. Up to 250 psi supply pressure, pipe sizes from ¼ to ¾ NPT.

Drift-free, lever set model 3500



The direct acting KENDALL: also available in a wide flow range, these force-balanced types are designed for operation at up to 250 psi supply pressure. Pipe sizes from ¼ to ⅜ NPT.

STRATOS

INDUSTRIAL PRODUCTS BRANCH

A division of Fairchild Engine and Airplane Corp.

Route 109, West Babylon, N. Y.

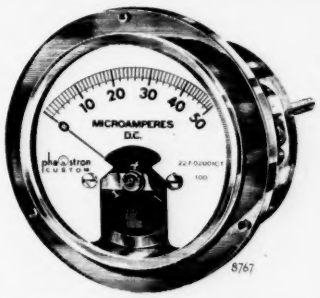
For more information circle **90** on inquiry card.

er). Resolution time is 8×10^{-11} sec or smaller; smallest phase angle in degrees which can be read on the dial is $\approx 8 \times 10^{-11} \times 360 \times$ frequency in cps. Frequency range 100 kc to 15 Mc (upper limit can be extended to 20 Mc with relaxing accuracy; lower limit to 10 kc with smaller phase range.)—*Advance Electronics Lab., Inc.*, 249-59 *Terhune Ave., Passaic, N. J.*

For more information circle **272** on inquiry card.

CORE MAGNET MOVEMENT

New core magnet instrument movement assures good linearity for 100° of scale arc, and sensitivities as low



as 20 uamp with a coil resistance of 3000 ohms. Better than average spring torque provides ample stability. Structural advantages include sintered rings and pole faces, precision die cast brackets, shock-mounted jewel assemblies.—*Phaostron Instrument and Electronic Company*, 151 *Pasadena Avenue, South Pasadena, California.*

For more information circle **273** on inquiry card.

PANEL-MOUNTING DC VTVM

New improved "Model F" dc vacuum tube voltmeter can be mounted without exceeding area required by

a standard panel instrument; features a higher accuracy (2%), wider range (0.5 v zero center to 300 v full scale), zero adjustment while connected to circuit, 10 meg input impedance and built-in amplifier and power supply. —*Trio Laboratories, Inc.*, 4025 *Merrick Road, Seaford, N. Y.*

For more information circle **274** on inquiry card.

DIGITAL OHMMETERS

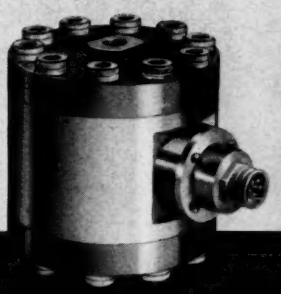
New "Models 758 and 759" provide fast automatic measurement of unusually wide ranges of resistance

MODELS PL80 AND PM80

Differential Pressure Transducers

FOR

flow measurement



AT

Rocket Engine Stands
Hydraulic System Tests
Nuclear Reactors

the flow of liquids and gases is being measured by connecting Model PL80 and Model PM80 pressure transducers across an orifice.

Ranges
±1 to ±3000 psid and 0-1 to 0-3000 psid

Line Pressure Rating
5000 psig

Pressure Media
Fluids not corrosive to Types 303 and 347 stainless steel

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For additional data, please request Bulletin Nos. PL80TC and PM80TC

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For more information circle **91** on inquiry card.

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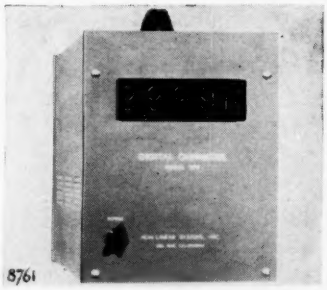
For more information circle **92** on inquiry card.

NEW INSTRUMENTS



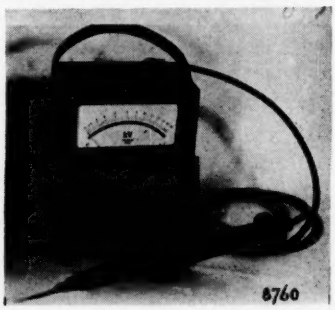
8761

values, with extremely small currents passed through test resistance; feature maker's oil-sealed stepping switch system; display resistance values by inch-high luminous numerals with decimal point and resistance symbol shifting automatically. Both models weigh 33 lb and are available in rack mount and portable styles.—*Non-Linear Systems Inc., Del Mar Airport, Del Mar, Calif.*

For more information circle **275** on inquiry card.

ELECTROSTATIC VOLTMETERS

New diversified line of electrostatic voltmeters comprises instruments with extremely high internal impedances,



8760

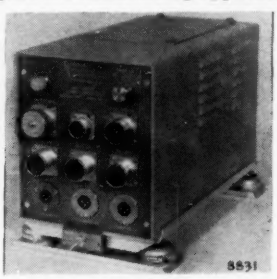
for both ac and dc measurements. Three main classes: (1) ranges from 0-150 v to 0-18 kv with accuracy of 1%; (2) ranges from 0-60 v to 0-100 kv with accuracy of 0.5%; (3) ranges from 0-100 kv to 0-600 kv.—*New England Scientific Instruments Co., Box* 408, *Cambridge* 39, *Mass.*

For more information circle **276** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

SIGNAL CONVERTER

New "Model 4-1103" three-channel high-level instrument signal converter, designed for telemetering applications,

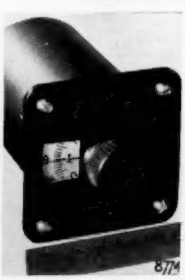


8831

is a modification of earlier "Model 108" low-level device designed for oscillographic recording. It converts signals from 400 cps pickups to 0-5 vdc by a crystal diode demodulator, eliminating all amplifiers from signal circuits, assuring gain and zero stability. —*Dynalysis Development Labs., Inc.,* 11941 *Wilshire Blvd., Los Angeles* 25, *Calif.*

For more information circle **277** on inquiry card.

VERNIER RESISTOR



8774

New "Vernier Potentiometer-Rheostat" is a four-terminal voltage divider which can be used as a voltage-dividing resistor or rheostat. It features a unique single-knob control of two decades: two turns cover full range. Resistance 10,000 ohms when used as a VDR and 0 to 10,000 ohms as a rheostat; accuracy 0.1% of full scale; linearity 0.1%; resolution 0.1% or better (equal to that of a ten-turn VDR); power-rating 4 watts when used as a VDR; current rating 25 ma when used as a rheostat. (Other resistance ranges available.)—*Research Instrument Co., PO Box* 9168, *Portland* 16, *Oregon.*

For more information circle **278** on inquiry card.

TURN-COUNT DIGITAL DIAL

8810

New ten-turn "Digidial," said to be "easier to read than an automobile odometer even at extreme angles of vision," gives direct numerical readings in full turns, tenths, and hundreths. Designed for use with many types of multiturn devices, it has a friction lock which can be engaged without disturbing dial setting.—*Beckman Helipot Corp., Newport Beach, Calif.*

For more information circle **279** on inquiry card.

INSTRUMENT TRANSLATOR FOR AIRCRAFT AND MISSILES

New transistorized instrument translator solves the problem of how to substitute variable-reluctance electromechanical pickoffs for variable-resistance types in aircraft and missile systems without adding considerable size and weight to electrical equipment. Various models are produced to operate indicators, recorders,

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WHAT'S NEW AT BRISTOL...

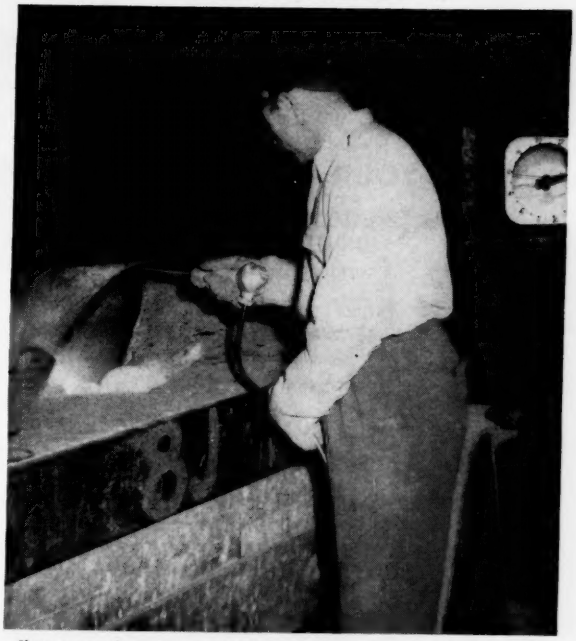

Photo courtesy General Thomas J. Rodman Laboratory, Watertown (Mass.) Arsenal.

NEW!

Immersion thermocouple for molten metals measures to 3200 F

The new Bristol portable immersion-type thermocouple is designed for direct measurements in melts of both ferrous and non-ferrous metals. Simplicity and operating economy are its key features.

Rugged tubes give economy. Latest result of Bristol's continuous development program in instruments and accessories for pyrometry, the new thermocouple's durable protection tube can take up to 14 dips in molten steel at 2700 F to 3200 F. Metals of lower melting temperatures such as brass and aluminum will give far longer life. What's more, replacement of the protection tube, plus reasonable care, allows re-use of the platinum sensing element—most expensive part of the unit.

Standard and "high-speed" models. The standard model of the new thermocouple—full response 30-45 seconds—features a Bristol metal-ceramic (LT-1) secondary protection tube. A special "high-speed" model—response 15-20 seconds—has a single quartz protection tube with quick-change thumbscrew, designed for easy replacement.

STOCK PARTS CUT COSTS, SPEED SERVICE

All parts in the new molten metal thermocouple are stock parts—a product of Bristol's careful design and advanced manufacturing methods. Result: lower first cost due to production economies and faster delivery on replacement parts.

Write today for complete data on this outstanding Bristol contribution to instrumentation in metallurgy. The Bristol Company, 154 Bristol Road, Waterbury 20, Connecticut. 7.1

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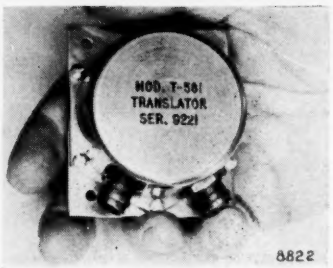
NEW INSTRUMENTS



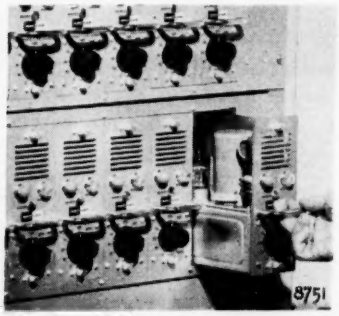
valves, servomotors, etc. All withstand severe environmental conditions without damage. No moving parts; no adjustments necessary.—*Crescent Engineering & Research Co.*, 5440 *N. Peck Rd., El Monte, Calif.*

For more information circle **280** on inquiry card.

AMPLIFIERS

BROADBAND DC AMPLIFIER

New "Model 111AF" floating-input broadband dc amplifier, designed for use with thermocouples, strain gages

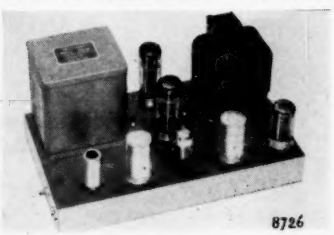


and other pickups that are grounded at pickup location, features extremely low eqivalent input noise: 60-cps noise current is less than 2 uamp per volt of potential difference between amplifier power source ground and pickup ground.—*Kay Lab.*, 5725 *Kearny Villa Road, San Diego* 11, *Calif.*

For more information circle **281** on inquiry card.

HI-FI AMPLIFIER

New "HF 60" 60-watt high-fidelity power amplifier, available in both kit and wired form, features "ACRO TO-



330" output transformer; "incredibly low price."—*Electronic Instrument Co., Inc.*, 84 *Withers St., Brooklyn* 11, *N. Y.*

For more information circle **282** on inquiry card.

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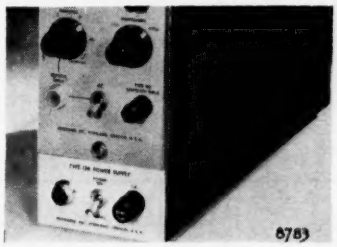
For more information circle **97** on inquiry card.

POWER SUPPLIES

INSTRUMENT POWER SUPPLY

New "Type 126" delivers voltages and currents to power one "Type 360 Indicator" or any one of "Type 160-

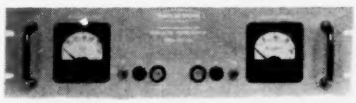


Series" waveform generators; mounts beneath unit can be powered; includes a cabinet to house both it and powered unit.—*Tektronix Inc.*, 9450 *S. W. Barnes Rd., Portland, Ore.*

For more information circle **283** on inquiry card.

LABORATORY POWER SUPPLIES

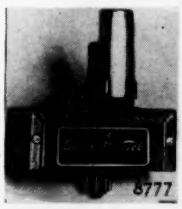
Two new lab power supplies give different output ranges: "Model PS-L225" for 125-325 v @ 0-200 ma dc,



6.3 v @ 10 amp ac; and "Model PS-L425" for 325-525 vdc range. Both have regulation better than 0.25% against load and line and ripple less than 3 mv rms; are designed for heavy-duty continuous operation; incorporate protection against overloads or internal failure. Input 105-125 v, 50-400 cps.—*Reflectone Corp., Stamford, Conn.*

For more information circle **284** on inquiry card.

PRECISION DC SUPPLY



New improved model of maker's "Constant Reference Voltage Supply" converts 115 vac into a highly stable dc voltage adjustable from 0 to about 87 v; is designed primarily as reference voltage for adjustable-speed motor drives and dc servo systems but can replace standard cells, wet or dry cells, and more extensive electronic regulating systems. Stability better than 0.2% maintained with load not exceeding 1 ma at ambient temperature range of −50°C to 40°C and with line voltage from 90 to 135 volts.—*Servo-Tek Products Co., 1086 Coffle Road, Hawthorne, N. J.*

For more information circle **285** on inquiry card.

COMPUTER POWER SUPPLY

New dc power supply with steady-state regulation accuracy of 0.01% has a ripple of less than 50 mv peak

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For more information circle **98** on inquiry card.

New!

MEASUREMENTS' FM

Standard Signal Generators

MODEL 210 SERIES

Measurements' Model 210 Series of Standard FM Signal Generators is designed for FM receiver measurements in the standard FM band; for measurements on railroad and automobile FM radio systems, research on FM, multiplexing and telemetering equipment. Models are available for use within the limits of 30 to 200 Mc each with a tuning range of approx. 1.2; for example, Model 210-A, 86 to 108 Mc.

FEATURES:

- Wide deviation with low distortion.
- Low spurious residual FM.
- Models coverings 30 to 200 Mc.
- Accurate output voltage calibration — low VSWR.
- Operates at fundamental carrier frequencies.
- Vernier electronic tuning.

SPECIFICATIONS:

FREQUENCY RANGE: Five different models, each with tuning ratio of approx. 1.2, cover range from 30 to 200 Mc.

TUNING: Vernier frequency dial, and electronic tuning for frequency deviation.

OUTPUT VOLTAGE: 0.1 to 100,000 μv.

OUTPUT SYSTEM: Mutual-inductance attenuator with 50-ohm source impedance with a low VSWR.

MODULATION: Selectable 400 and 1000 cycle internal audio oscillator. Other modulation frequencies available.

MODULATION FIDELITY: Frequency deviation response within ± 0.5 db from d.c. to 15,000 cycles, within 3 db to 70 Kc.

RESIDUAL FM: Spurious residual FM 60 db below 75 Kc. deviation.

POWER SUPPLY: 117 v., 50-60 cycles, 45 watts.

(complete data on request)

Laboratory Standards

MEASUREMENTS CORPORATION

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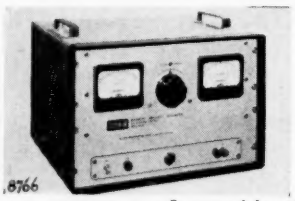
For more information circle **99** on inquiry card.

NEW INSTRUMENTS



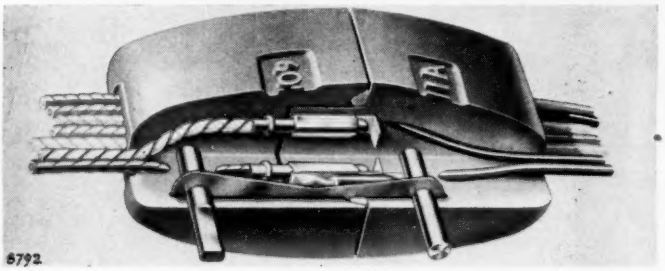
8766

to peak and a dc output of 200 v ±10% @ 3 amp. Dynamic regulation is 1% for 50% load change or 15% ac line change (ac input 208/230 v, 3 phase, 60 cps ±15%). Other features: extremely low dynamic impedance; ultra-fast magnetic amplifier with instantaneous electronic control; no saturating type ac regulators or large energy storage capacitor banks.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

For more information circle **286** on inquiry card.

ELECTROMECHANICAL COMPONENTS

INTEGRALLY-MOLDED-INSULATED CONNECTORS



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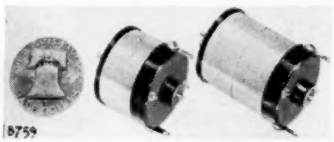
New multicontact connectors, said to represent "the first major breakthrough in connector reliability since potting," result from unique design and special production processes called "IMI (integral molded insulation) Connector Technique" which makes it possible to supply molded unit cables in which contacts and leads are molded with one hot shot of connector insulation into connector bodies integral with their cables. New designs eliminate tedious and critical assembly operations, minimize number of parts in connectors, provide positive moisture seal and protect leads and contacts from shock and vibration, thus maximize reliability.—*Dept. AUC 127, Alden Products Co., 117 N. Main St., Brockton, Mass.*

For more information circle **287** on inquiry card.

MINIATURE DC MOTOR

New type of low-cost dc motor weighs less than 2 oz for small model, is practically noiseless and vibration-



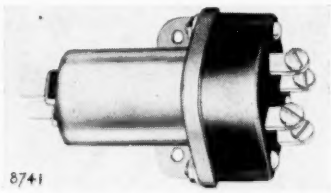
8759

less; available in speeds from 1600 to 15,000 rpm, voltages from 1.3 to 16; features self-aligning nylon or oilite bearings which do not require lubrication; silver-treated replaceable brushes guaranteeing life in excess of 100 hours.—*Minitone Inc., 55 W. 13th St., New York 11, N. Y.*

For more information circle **288** on inquiry card.

HEAVY-DUTY RELAY

"Powerloid" is a power-type electromagnetic switch actuated by a solenoid plunger. It combines characteristics of a relay and a solenoid; has been tested for 230 vac motor loads up to 3 hp power and for heater units up to 8400 w. Available contact combinations; sp-st dual make; sp-st dual break; sp-dt dual make and dual



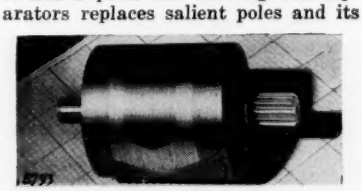
8741

break; also with sp-st dual make or sp-st dual break utilizing an auxiliary switch on outside of switch housing. Coils are standard voltages up to 230 vac and to 110 vdc.—*Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.*

For more information circle **289** on inquiry card.

BRUSHLESS ALTERNATOR

New synchronous alternator developed for ultrahigh-speed applications operates without rotating windings: a smooth metallic cylinder (illus.) with N and S poles and nonmagnetic separators replaces salient poles and its



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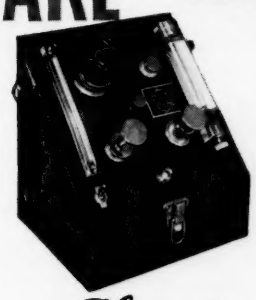

Any shop man can quickly...accurately...read dew points with the Dewpointer. It is the only instrument that lets you see the fog in a sealed chamber under controlled conditions. Compare this fast, positive method with attempts made to tell exactly when fog forms on a mirrored surface. Completely self-contained, requires no external coolant or auxiliary apparatus ...operates on enclosed battery or AC. Available in three ranges for dew points between −20° F. and room temperature, from −80° to 0° F. and −80° F. to room temperature.

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For more information circle **101** on inquiry card.

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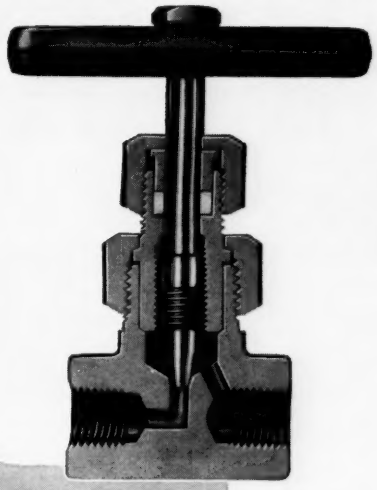

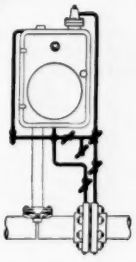

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Standard valves design rated for pressures to 5,000 psi at 70°F. For pressures to 10,000 psi, upon request, valves are hydrostatically tested and individually inspected. Valves are furnished with graphite-impregnated asbestos packing for temperatures above 450°F.

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For more information circle **102** on inquiry card.

speed is limited only by bearing lubrication and centrifugal-force stresses: tests at 60,000 rpm were successful. New machine can operate as a synchronous motor, alternator or doubly-fed motor. As a dynamoelectric rotating amplifier, input to high-impedance field winding can control an output several hundred times larger. —*Bekey Electric Co., Inc.*, 1327 *South Main St., Los Angeles* 15, *Calif.*

For more information circle **290** on inquiry card.

1-DEG. STEPPING SYNCHRO

New "Model 89161-A precision stepping synchro utilizes "Rotostepper" electromechanical positioner to drive

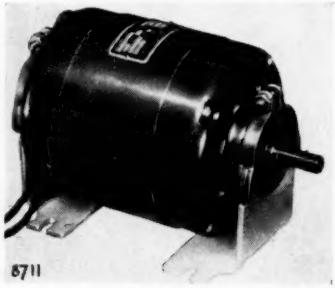
8739

rotor of a differential synchro in fixed increments of one degree; produces an ac output synchronous with rotor position. Rotation unlimited in both directions. Operation by an electrical input pulse at any speed up to 60° per second.—*G. M. Giannini & Co., Inc., Pasadena* 1, *Calif.*

For more information circle **291** on inquiry card.

FRACTIONAL-HP MOTOR

New "Type U" split-phase induction motor, in Ratings of 1/20 and 1/15 hp at 1725 rpm and 1/30 hp at 1125

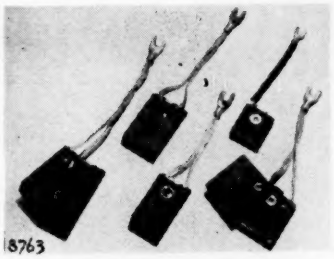

8711

rpm, has been field tested for several years and is now offered for general application. It is available with resilient mounting, thermal overload protection and centrifugal cutout.—*Bodine Electric Co.*, 2254 *W. Ohio St., Chicago* 12, *Ill.*

For more information circle **292** on inquiry card.

GRAPHITIC BRUSHES

New "D Series" of brush grades are unaffected by adverse physical and atmospheric conditions which gradually reduce commutator efficiency when ordinary brushes are used. Example: continuous operation of a crane in fumes over plating or pickling baths. "D Series" electrographitic lamp-black brushes feature low friction, good carrying capacity, and high commutation factor for severe commutating conditions; also film-forming properties needed while operating under adverse atmospheric conditions.—*The Ohio Carbon Co., Dept.* 186, 12508 *Berea Road, Cleveland* 11, *Ohio.*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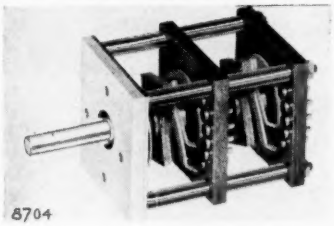
For more information circle **293** on inquiry card.

CUSTOM-BUILT SWITCHES

New "DES" series of switches is result of demands for "CES" switches with sub-standard mounting dimensions. Maker's entire switch line now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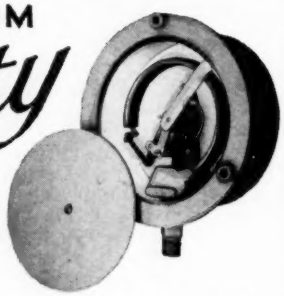
FOR MAXIMUM

Safety



Rear view of Safety Gauge showing safety plate and metal wall separating bourdon from scale

All Weksler pressure gauges can now be furnished with the SG SAFETY GAUGE feature. In the event of bourdon tube rupture due to excessive pressure, corrosion or other weakening factor, this mechanism allows the back plate to lift, releasing the pressure force without becoming detached from the instrument. This ingenious device thus affords safety both in front and back of gauge.

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This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

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SPECIFICATIONS:

- **Line voltage:** 105 to 130 volts at 60 or 400 cps
- **Nominal power output:** 4 watts
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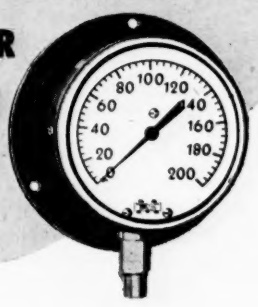

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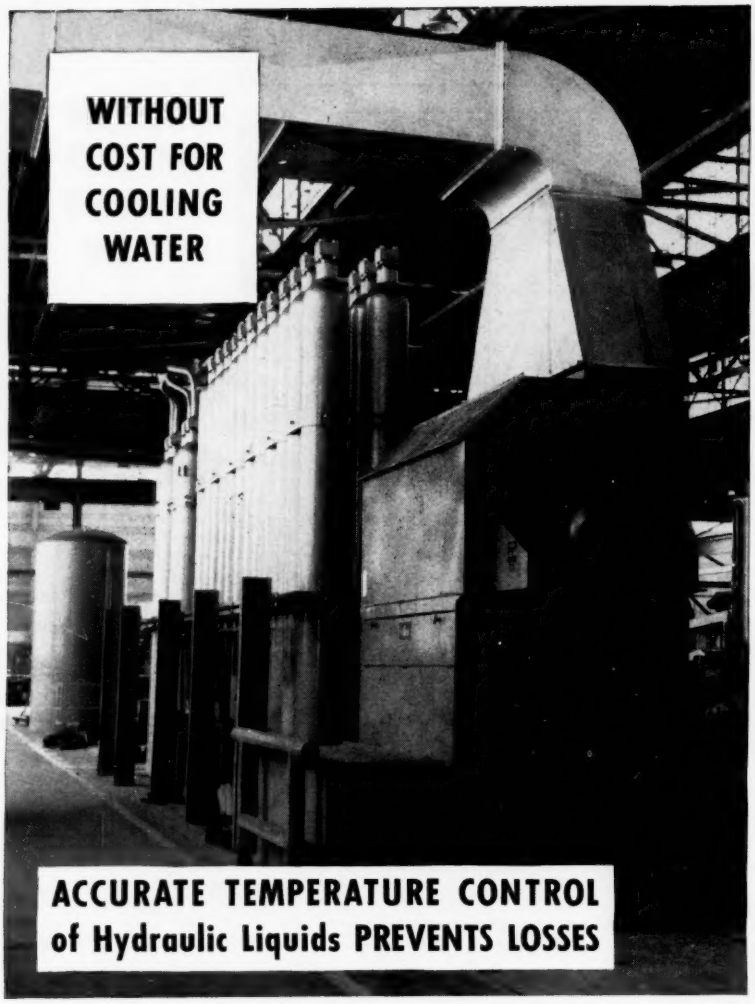

● This NIAGARA AERO HEAT EXCHANGER cools the liquid for a large hydraulic press, preventing heat damage to the pump stuffing boxes. Using outdoor air as the evaporative cooling medium, it removes the heat at the rate of input (1,875,000 BTU/hr.) with no cooling water consumption except a negligible amount evaporated.

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Similar Niagara machines cool water, oils, solutions, lubricants and coolants for many mechanical, electrical and chemical processes. You can cool quench baths, welding machines, plastic molds, furnaces, controlled atmospheres, gases, compressed air either for power or instruments or processes. In a closed system, your coolant is never contaminated. The system is simple and easy to keep up; the equipment has a long, useful life. Select from a wide range of sizes up to 30,000,000 BTU.

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NIAGARA BLOWER COMPANY

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Niagara District Engineers in Principal Cities of United States and Canada

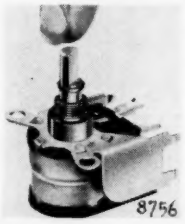
For more information circle **107** on inquiry card.

NEW INSTRUMENTS

becomes available as replacement for existing substandard mounting dimensions. New switches are equipped with stainless steel shafts; are custom-built with production parts prefabricated for speedy delivery. Variations in accessories include special terminal boards, dust covers, ball bearings, stainless shafting, coin silver contacts, special detent positions and high-voltage construction.—*Aerovox Corp., Cinema Engineering Div., Burbank, Calif.*

For more information circle **294** on inquiry card.

PUSH-PULL SWITCH



New type of line switch featuring push-pull action is available on maker's printed circuit type volume controls. It closes line circuit when control shaft is pulled out and opens circuit when shaft is pushed in. This obviates need for readjustment of volume every time set is turned on; also eliminates accelerated wear on lower end of resistance element.—*P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.*

For more information circle **295** on inquiry card.

MINIATURE SOLENOIDS

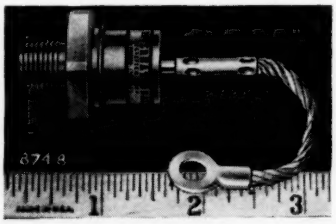
New complete line of miniature solenoids comprises units of many sizes from thumbnail up. Most units can be used in aircraft, memory units, computers, etc. Mounting brackets are furnished to meet application need. Some models are available for immediate delivery.—*West Coast Electrical Mfg. Corp., 233 W. 116th Place, Los Angeles 61, Calif.*

For more information circle **296** on inquiry card.

ELECTRONIC COMPONENTS

SILICON POWER DIODES

New silicon power diodes for industrial and military applications are rated to deliver 14 to 70 amp (half-

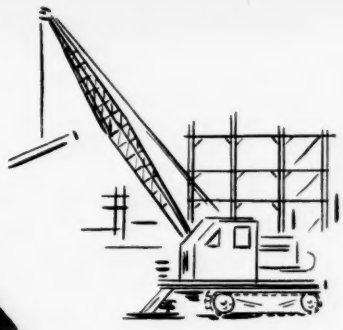


wave rating), are available in voltage ratings of 50 to 300 PIV; can be connected in all standard circuit types. For example, six diodes assembled on proper heat sinks and connected in a

MISSILES to MACHINERY

Century MODEL 420 ELECTROGRAPH

covers the oscillograph recording field



TELEMETRY APPLICATIONS

- QUICK-LOOK monitoring in the telemetry ground station permits continuous observation of missile in-flight programing results.
- ON-THE-SPOT monitoring permits making in-flight function corrections in controlled missiles or piloted aircraft.
- A NATURAL for mobile telemetry vans . . . compact, rugged, low power consumption, record is PERMANENT, no fading or fogging when exposed to direct sunlight.

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- STRESS-STRAIN RECORDING with "first-hand" read-out during test.
- PERMANENT record obtained at test site may be stored indefinitely for purpose of future data reduction.
- PORTABLE — extremely useful for field test applications where a "multiplicity" of data must be collected with the least amount of instrumentation.
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- Permanent continuous record produced within recorder.
- Developed record may be viewed an INSTANT after exposure.
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FEATURES

A micro-microammeter and millivoltmeter in one instrument • Measures currents from 10^{-16} to 10^{-7} amperes • 10, 100, and 1,000 mv ranges plus recorder output • Exclusive, diaphragm-type dynamic capacitor provides longer life, greater stability and reliability • High stability, both short and long term • Extremely high input impedance—10^{15} ohms • Better than 2% accuracy • $1,075.00 F.O.B. Carlstadt, N. J.

TYPICAL APPLICATIONS

Electronics:
Measurement of semi-conductor parameters, low-level voltages, static charges, floating grid potentials, grid currents, residual noise in summing amplifiers, and insulation resistance

Physics and Chemistry:
Mass spectrometry, pH measurements

Nuclear:
Reactor control and radiation monitoring systems

Industrial:
Beta and gamma gauge control systems

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Measurement of stomach acidity, skin and cell potentials, nerve impulses, etc.

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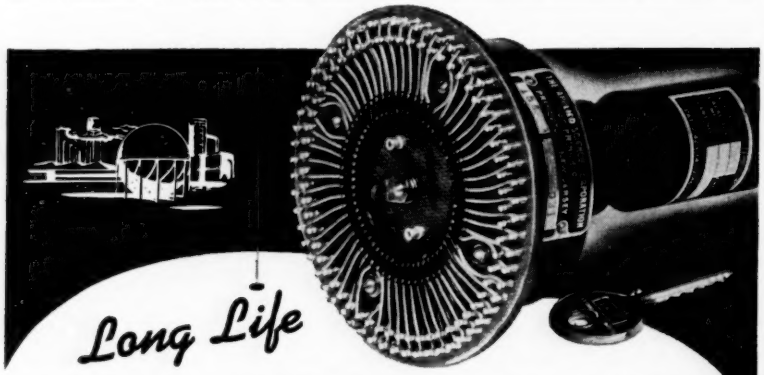

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ASCOP, the leading manufacturer of rotary sampling switches, for industrial, scientific and military uses, has over 200 standard models for automation, instrumentation, telemetering, display and countless other applications.

ASCOP switches feature reliability, accuracy and trouble free operation. Up to 240 contacts per pole are available. Whether your problem requires a standard switch or a special design, rely on the leader . . .

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NEW INSTRUMENTS

three-phase bridge can supply 13 kw at 175 vdc with natural convection cooling or 33 kw at 175 vdc when forced-cooled. Units are hermetically sealed and mechanical construction is designed for excellent stability and reliability.—*International Rectifier Corp., El Segundo, Calif.*

For more information circle **297** on inquiry card.

CONTINUOUSLY-VARIABLE DELAY LINES

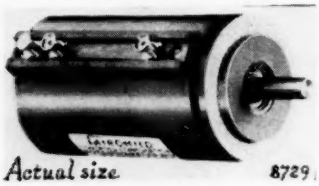
New "Model 404," $6\frac{17}{32}$" long, is designed for use as a component or as test equipment in advanced computer and radar systems; offers maximum in application flexibility: entire delay range, from zero to maximum delay, is covered by ten turns of one control shaft. A locking device (on "Model 404B") or hermetically-sealed shaft (on "Model 404C") is available at no extra charge. Attenuation is less than 1db; resolution is better than 0.001 usec. New unit has a high impedance tap (variable), and can be operated above ground potential. Maximum delay 0.50 usec; maximum rise time 0.055 usec; impedance 750 ohms. ★Six other new variable delay lines feature maximum delays from 0.10 to 0.50 usec, maximum rise times from 0.025 to 0.060 usec, and impedances from 100 to 1500 ohms.—*ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **298** on inquiry card.

VARIABLE RESISTORS

TEN-TURN VDRs

New "Type 907" (phenolic) and Type 908 (metal case) ten-turn precision voltage-dividing resistors are



Actual size 8729

⅞" dia units with 3600° electrical rotation; resistance values from 100 to 100,000 ohms. "Type 907" linearity 0.1% to 0.50%, "Type 908" 0.05% to 0.25%. Ratings at 40°C are 2 and 2½ watts respectively. A special long-life feature has been incorporated in "Type 908": mechanical drive separate from helical coil of resistance wire, thereby eliminating wear on coil. Standard units' ambient temperature operating range −55°C to 85°C; special to 150°C at which temperature power rating derates to zero. (At 85°C standard units are normally derated to 15% of rated wattage.)—*Components Div., Fairchild Controls Corp., or 225 Park Ave., Hicksville, N. Y.*

For more information circle **299** on inquiry card.

JEWEL-BEARING VDR

New jewel-bearing sub-miniature "Acepot" precision wire-wound voltage-dividing resistor features ex-

tremely low torque (0.01 oz-in); is recommended for instruments, computers, etc. Resistance range 10 ohms to 0.25 megohm standard (higher or lower on special order); linearity 0.3%; power rating 2 watts for 60°C rise; weight ¼ oz including lock washer and nut; temperature range −55°C to 150°C; meets applicable portions of JAN specs and MIL-E-5272A.—*Ace Electronics Associates, Inc.*, 103 *Dover St., Somerville* 44, *Mass.*

For more information circle **300** on inquiry card.

PRECISION MINIATURE VDRs

New subminiature "Acepots" feature linearity of 0.1% and, though only ½" in size, are available in resistance range of 10 ohms to 0.25 megohm. Operational characteristics, dependability, and life expectancy are equal to that of larger units. All units fully sealed, moistureproofed, antifungus treated; meet applicable portions of JAN specs and MIL standards. Prompt delivery on production units.—*Ace Electronics Associates, Inc.*, 103 *Dover St., Somerville* 44, *Mass.*

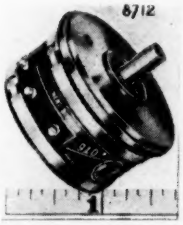
For more information circle **301** on inquiry card.

HI-TEMP MULTITURN VDR

New "85177A" is a high-temperature infinite-resolution unit added to "Spiralpot" line of slide-wire type precision voltage-dividing resistors. Use of special materials and alloys allows a power rating of 1.5 watts at 150°C. Available with linearities of 0.1% and 0.05%; standard resistance values 50, 100, 150, 200, and 250 ohms per turn in ten-turn units. (Less-than-10-turn rotations and resistance values as low as 2 ohms per turn are also available.)—*G. M. Giannini & Co.*, 918 *E. Green St., Pasadena* 1, *Calif.*

For more information circle **302** on inquiry card.

PRECISION VDR



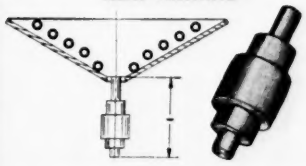
New "910 Series Single Turn Micropot Potentiometer" is a high-precision (0.5% independent linearity) voltage-dividing resistor with resistance element and terminal

The Lepel line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

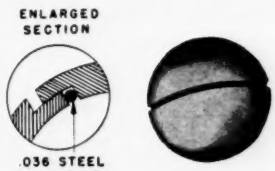
TYPICAL INDUCTION HEATING APPLICATIONS

TEMPERING FOR CUSTOM HEAT TREATING



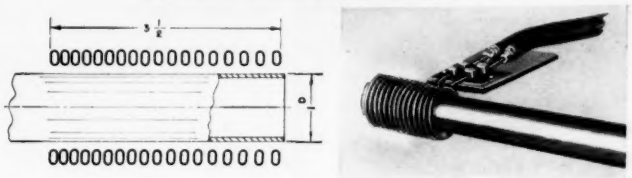
Selected areas of hardened steel parts may be tempered for fabrication or service requirements. Concentrator type coil permits high power density in restricted area thus minimizing heating time and permitting marked variation in properties in adjacent sections.

WIRE RING JOINS PLASTIC PARTS



High frequency induction heats wire ring which in turn heats plastic wall, providing sufficient plasticity to cause flow and bonding upon application of pressure. Metal to plastic seals are similarly performed.

ANNEALING ALUMINUM FURNITURE TUBING



Selective annealing of aluminum furniture tubing permits bending where required without loss of strength in adjacent portions of tube. Brass or steel tubing is also being selectively annealed.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

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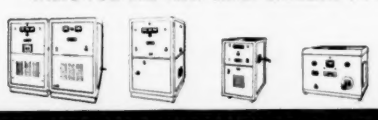

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For more information circle **113** on inquiry card.

NEW INSTRUMENTS

leads molded into a single unit for reliable operation under severe vibration and high temperature conditions. Units can be ganged; each cup can be individually phased in the field; all models have ball-bearing shafts. Power rating 5 watts at 40°C; resistance range 50-10,000 ohms (50,000 ohms special); starting torque 0.5 oz-in per section; continuous mechanical rotation; 340° max electrical rotation; net weight 4 oz for first unit and 1 oz for each additional unit. Meet or exceed all commercial and military environmental requirements. —*George W. Borg Corp., Janesville, Wis.*

For more information circle **303** on inquiry card.

TRIMMING VDRs

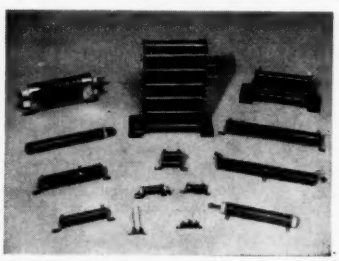
New "Models 50 and 52," available in resistance values from 500 to 20,000 ohms in standard models, feature unique design which makes use of a glass-film resistance element fused to a tough ceramic frame. A stainless steel adjusting shaft rides on cast metal bearings metallically bonded to ceramic frame to assure proper alignment and to prevent backlash. Contact carrier is a heat-resistant Teflon block and contact is a precious-metal multifinger spring. Power rating 1.5 w at ambient temperatures up to 120°C, derating to zero at 200°C. Mechanical life expectancy at least 1,000 cycles or 70,000 shaft revs.—*Helipot Corp. Div. Beckman Instruments, Inc., Newport Beach, Calif.*

For more information circle **304** on inquiry card.

FIXED RESISTORS

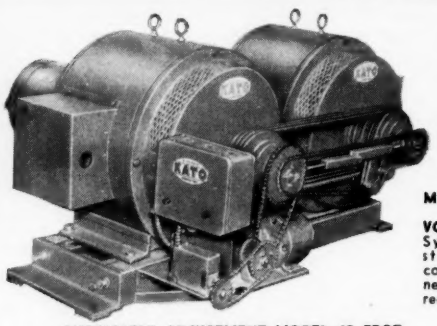
VITREOUS ENAMELED RESISTORS

New fixed and adjustable vitreous enameled resistors covering range from 5 to 200 watts are available with a wide variety of mounting arrangements such as fuse-clip, heavy-duty, bracket, thru-bolt, hot feet, and screw-base. Among features: sturdy ceramic core of high density, high dielectric strength and low porosity; low temperature coefficient resistance wire; high tensile strength terminals; silver-brazed junction between resistance wire and terminals; elimination of



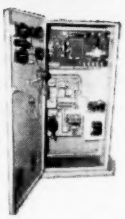
For Better Bench Mock-Up Tests

KATO VARIABLE FREQUENCY MOTOR GENERATOR SETS



REMOTE CONTROL
Remote control frequency adjustment varies speed from 1080 to 1320 RPM, thus varying frequency. Bench mock up test station may be located anywhere.

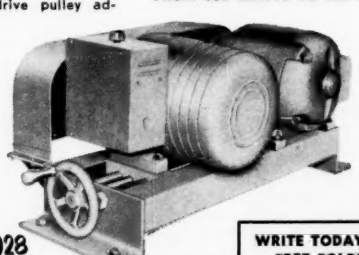
MAGNETIC AMPLIFIER AUTOMATIC VOLTAGE REGULATOR
Synchronous motor starter and generator controls, including magnetic amplifier voltage regulator in cabinet.



AUTOMATIC ADJUSTMENT MODEL 45 EPOT
Fully automatic variable frequency motor generator set adjusts 360 to 400 CPS. Generator mounted controls include reset buttons, Cutler-Hammer Limit Switch. Motor and generator remain stationary. Vari-drive pulley adjustment controlled by small motor.

A. C. GENERATORS • 60 CYCLE FROM 350 WATTS TO 500 KVA.

MANUAL ADJUSTMENT MODEL 28XA08
Easily adjusted by simple hand wheel controlling variable pitch pulley V-belt arrangement. This motor generator set gives 45 to 60 cps output. Unit holds speed accurately. Frequency meter on generator panel indicates output. Single phase generator speed varies from 1350 to 1950 rpm.



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IT'S NEW!

For more information circle **112** on inquiry card.

"hot spots"; moistureproof enamel core that forms a mechanically airtight casing for resistor winding. New units conform to RETMA and NEMA standards and are available in both stock and made-to-order ratings.—*Industry Control Dept., General Electric Co., Roanoke, Va.*

For more information circle **305** on inquiry card.

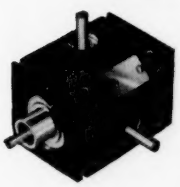
POWER RESISTORS

New improved miniature metal-clad chassis-mounted precision power resistors have internal temperature rise 25% less than in previous models. Reduced hot-spot temperature is achieved by use of a unique filling material between precoated resistor and black anodized aluminum case. This material has exceptional heat-transfer ability, and is injected to seal against humidity. Available in nominal power ratings of 25 and 50 watts, these resistors will dissipate 80% of rated power at 40°C ambient while maintaining an internal hot-spot of only 260°C. This contrasts with MIL-R-18546 requirement of 60% of rated power at 275°C hot-spot.—*Sage Electronics Corp., 302 N. Goodman St., Rochester, N. Y.*

For more information circle **306** on inquiry card.

MECHANICAL COMPONENTS

SPHERE RESOLVER

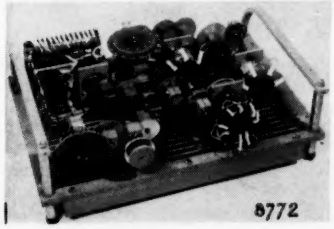


New miniaturized precision mechanical ball resolver has 0.1248" dia input shaft that can be driven up to 100 rpm and requires less than 5 oz-in at 25°C for an input of 1 to 2 oz-in at 0.187° dia sine and cosine output shafts. Its 0.500" orientation shaft is concentric with input and establishes output relation with accuracy of 0.5% over a 360° range.—*Vectron, Inc., 1568 Trapelo Road, Waltham 54, Mass.*

For more information circle **307** on inquiry card.

SERVOMECHANICAL PARTS

New parts designed especially for airborne 400-cps servo systems in applications where space is at a premium and low system inertias are required, comprise all essential mechanical parts: not only dial assemblies,



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for every application

For hours in aircraft or minutes in missiles, gyros must possess ruggedness and dependability that will assure performance of the mission. Kearfott Gyros possess this ruggedness and dependability coupled with extremely high accuracy. That is why they are so widely used in all types of aircraft and missiles. Kearfott Vertical, Rate, Free, Directional and Floated Rate Integrating Gyros as well as Stable Elements are designed to meet the most stringent airborne requirements.

Unsurpassed in Performance Unequalled in Compactness

Kearfott Miniature Vertical Gyros satisfy the requirements of MIL-E-5272 as regards shock test (Procedure II) humidity, salt spray, fungus resistance, rain, sand, dust, immersion and explosion proof. Duplicates the performance of standard vertical gyros in ½ the volume and weight.

Write today for technical data on Kearfott Gyros.

KEARFOTT COMPONENTS INCLUDE:
Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

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A SUBSIDIARY OF GPL

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

For more information circle **114** on inquiry card.

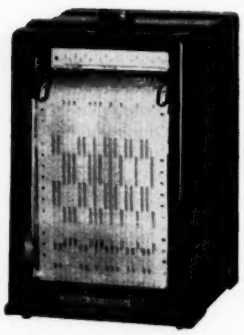
ARE THESE PROBLEMS BOTHERING YOU?

- Productive and idle time?
- Flow of materials?
- Position of gates and dampers?
- Time of failure in life tests?
- Length of phone calls?
- Sequence of switching?
- Timing of events?

The operation recorder will obtain the answers to these problems, and many more, for you. An instrument with 20 pens writing on a moving chart, the operation recorder shows:

- *When events occur*
- *How long they last*
- *How frequently they occur*
- *The relationship of a series of events to each other*

Product Representatives in Most Principal Cities



Write for Bulletin 247A, *"Operation Recorders—Their Selection and Use."*

The ESTERLINE-ANGUS Company, Inc.

Pioneers in the Manufacture of Graphic Instruments

Dept. G3, P. O. Box 596, INDIANAPOLIS 6, INDIANA

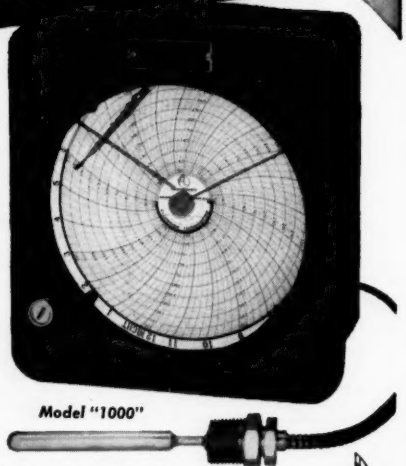
For more information circle **115** on inquiry card.

AUTO-LITE

TEMPERATURE RECORDING...

Newly designed, Model "1000" Auto-Lite Recorder gives permanent proof of temperature behavior. • 6" clear reading chart; various standard ranges from minus 40°F. to plus 550°F. • 3 standard types; choice of 24-hr. or 7-day cycle. • Electric or mechanical chart drive. • With capillary tubing for remote reading. Priced from $49.50.

Send for new catalog describing many styles of Auto-Lite temperature Recorders and Indicators.



Model "1000"

THE ELECTRIC AUTO-LITE COMPANY
INSTRUMENT AND GAUGE DIVISION
TOLEDO 1, OHIO
NEW YORK • CHICAGO • SARNIA, ONTARIO

TEMPERATURE RECORDERS

For more information circle **116** on inquiry card.

NEW INSTRUMENTS

couplings, differentials, etc., but a complete line of precision class II gears; can be purchased separately or in kit form.—*Reeves Instrument Corp., 207 E. 91st St., New York 28, N. Y.*

For more information circle **308** on inquiry card.

BALL-AND-DISC INTEGRATORS

New ball-and-disc integrators, for use in computing systems, as control or sensing elements in servo systems, or as servo-system output in rate generators, have ball carriage with 2" maximum travel, and recommended maximum output torque is 5 oz-in. Torque required to move ball carriage at its input shaft is 1 oz-in; maximum disc input torque required at zero load is 3 oz-in; maximum recommended speed 1,000 rpm. Disc is hardened to Rockwell C65 and precision lapped to superfinish.—*Beckman Helipot Corp., Newport Beach, Calif.*

For more information circle **309** on inquiry card.

GEAR BOXES

New precision-miniaturized gear boxes, available in three series, Sizes 11, 15 and 18, have a wide range of gear ratios, from 4:1 to 12,000:1. Size 11 gear box provides torque up to 45 oz-in; Sizes 15 and 18 up to 65 and 100 oz-in respectively. Precision ball bearings throughout; sealed permanently lubricated bearings on output stage.—*Southwestern Industries Inc., 5880 Centinela Avenue, Los Angeles, Calif.*

For more information circle **310** on inquiry card.

DIFFERENTIALS

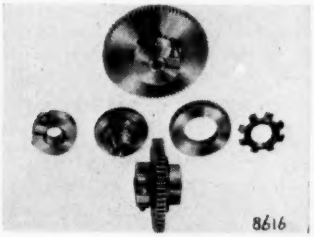
New "V10," "V11" and "V12" precision oil-less bearing differentials have all parts stainless steel except

aluminum spider gear. Lost motion between any two end gears is not more than 30 min. of arc. Immediate delivery in ⅛", 3/16" and ¼" shafts, 72, 64 and 48 pitch.—*Pic Design Corp., 477 Atlantic Ave., East Rockaway, N. Y.*

For more information circle **311** on inquiry card.

MINIATURE SLIP CLUTCH

New miniature slip clutch is available in 48, 64, 72, 80, 96 and 120 diametral pitch, from 0.750" to 1.500"



PD; 0.562" over-all with a choice of 0.1250" or 0.1875" bore. Torque setting by adjustable threaded locking clamp. All units are manufactured to Precision Class I tolerance.—*Dynamic Gear Co., Inc., 20 Merrick Rd., Amityville, N. Y.*

For more information circle **312** on inquiry card.

PNEUMATICS, etc.

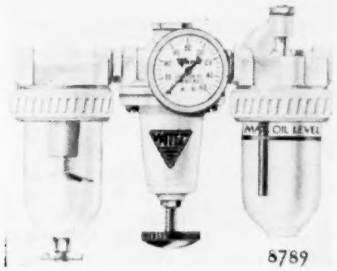
AIR LINE FILTERS

New and completely redesigned "Series 30AE" compressed air filters are said to "offer many notable advancements." Moisture removal efficiency has been stepped up; pressure drop has been further reduced; hinged-type clamp rings have chained clamp pin simplifying servicing; newly-designed louver plates set an improved centrifugal air flow pattern; larger filter elements enhance filtering efficiency. —*C. A. Norgen Co., 3400 S. Elati St., Englewood, Colorado.*

For more informtion circle **313** on inquiry card.

FILTER-REGULATOR-LUBRICATOR

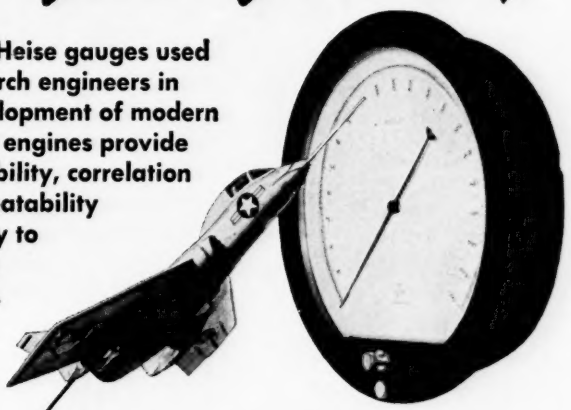
New combination units for automatic filtration, regulation and lubrication of air supply to pneumatically operated equipment, are available in ¼", ⅜" and ½" sizes. Filter features "tornado action" that throws foreign particles and condensation against sides of filter bowl where they spiral downward into the "quiet zone" for accumulation and drain-off. Regu-



HEISE GAUGES

Conquest of the Sky

Heise gauges used by research engineers in the development of modern turbo-jet engines provide the reliability, correlation and repeatability necessary to scientific progress.



Actual operating conditions are reproduced in the Cox Test Stand built by Commercial Research Laboratories to test for optimum efficiency of jet fuel nozzles.

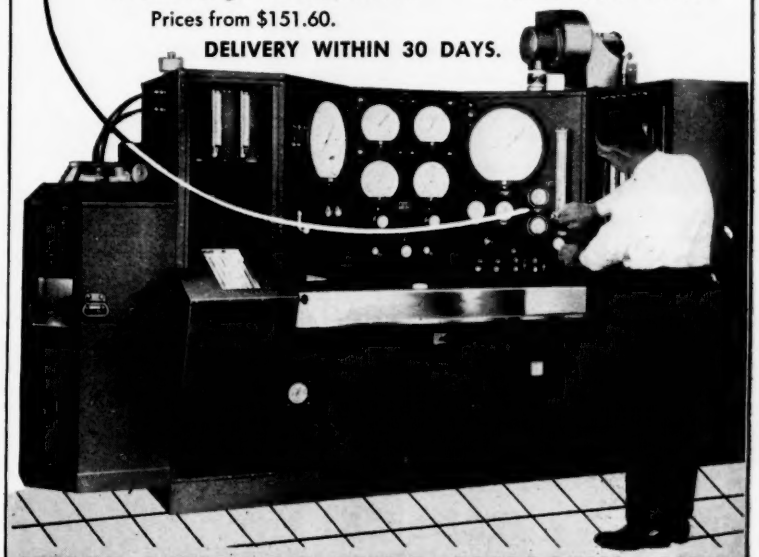
The six Heise gauges incorporated in the test stand feature in the vital and exacting performance which this instrument must accomplish.

Higher air speeds, rates of climb and economic fuel consumption, factors which every day reach and surpass new levels of efficiency, are made possible by the continuing efforts of research men equipped with today's most accurate instruments.

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $151.60.

DELIVERY WITHIN 30 DAYS.



HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **117** on inquiry card.

FOR *Vibration analysis*

THE TP-625 FREQUENCY ANALYZER

FEATURES

- LINEAR FREQUENCY CALIBRATION — Manual or Automatic Sweep
- EXCELLENT STABILITY — Temperature Controlled bridge-stabilized oscillator
- CONSTANT FREQUENCY BANDWIDTH — As narrow as 2 cps; as broad as 200 cps
- DYNAMIC RANGE — As great as 66 db (depending upon filter employed)
- SPECTRUM — 2 cps to 25,000 cps
- MULTICHANNEL ANALYSIS — Simultaneous analysis of numerous channels

The TP-625 Frequency Analyzer will determine the recorded frequency-amplitude spectrum of a random wave within the frequency range of 2 cps to 25,000 cps. In addition to analyzing random waves, the instrument will also determine the frequency and amplitude of the individual components in a periodic wave within this frequency range.

Wave components resulting from vibration, pressure, strain, light, etc., can be measured in decibels, in percent of total signal or both. Results are indicated on a calibrated attenuator and on a meter. For permanent, detailed analysis, high and low impedance output are provided to drive a recorder. When equipped with its accessory servo system, the TP-625 will follow RPM, or multiples of RPM, in engines throughout an operating range.

For specifications and further information, write for bulletin 625-1-956

Technical Products Co.
INSTRUMENT DIVISION
6670 Lexington Ave. Los Angeles 38, Calif.

For more information circle **118** on inquiry card.

MAGNETS

HIGH ENERGY PRECISION ALNICO PERMANENT MAGNETS

WE CARRY IN STOCK ALL SIZES, ALL SHAPES, ALL ALNICO GRADES . . .

When you need them — as you need them. Experimental or production quantities.

PERMAG
services include
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24 HOUR DELIVERY

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For more information circle **119** on inquiry card.

BALZERS Thin Film Optics

From the Principality of Leichtenstein Swiss Customs Area

ROLYN ARCADIA (Calif.)

Front Surface Mirrors, Cold Mirrors, Achromatic Beam Splitters, Dichroic Beam Splitters, Monochromatic Interference Filters, Wedge Interference Filters, Heat-Reflecting Interference Filters, Cut-Off Filters, Anti-Reflection Coatings, Heat Protective Coatings and many other thin layers.

CABLE ADDRESS "ROLYN" LOS ANGELES
PHONE: DOUGLAS 7-2300

Robert M. Lynn
(ROLYN COMPANY) -- ESTABLISHED 1923
OPTICAL — GLASS — PHOTO
319 North Santa Anita Ave. • Arcadia, California

ADDRESS REPLY TO P. O. BOX 745 ARCADIA, CALIFORNIA

Balzers means research in high vacuum process

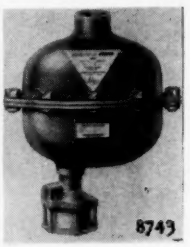
For more information circle **120** on inquiry card.

NEW INSTRUMENTS

lator features an aspirator which provides instant regulation of reduced pressure under widely varying flow demands. Lubricator is designed with a high-velocity Venturi section which maximizes vaporization and assimilation of metered oil.—*Industrial Div., Watts Regulator Co., Lawrence, Mass.*

For more information circle **314** on inquiry card.

AIR AND GAS TRAP



New "Mag-Pneu-Power" is of an entirely new type. It discharges condensate from compressed air or gas lines by a combination of magnetic, pneumatic and automatic action. Operation: As condensate rises, float does not rise, but is held firmly in place by magnet mounted on pivot arm. When force build-up of condensate working on float overcomes magnetic attraction, float snaps open pilot valve which, in turn, causes piston assembly to move upward and open main discharge valve.—*Hankison Corp.*, 951 *Banksville Rd., Pittsburgh* 16, *Pa.*

For more information circle **315** on inquiry card.

INSTRUMENT AIR DRYER

New desiccant-type dehydrator for use in instrument lines removes water vapor from compressed gases serving pneumatic equipment on dead-end or low-flow service in remote locations; provides a dew point of −60°F or lower; can be used at pressures to 100 psig and has a capacity of 60 scfh at 70°F. Dryer consists of a head, a case, and an inexpensive desiccant cartridge. Head is mounted "straight through" in line and does not have to be removed for servicing. Saturation indicator in head turns from blue to pink when cartridge needs changing. (Change quickly made without tools; saturated cartridge reactivated by heating in an oven.)—*King Engineering Corp., Box* 645, *Ann Arbor, Mich.*

For more information circle **316** on inquiry card.

H-P QUICK DISCONNECT

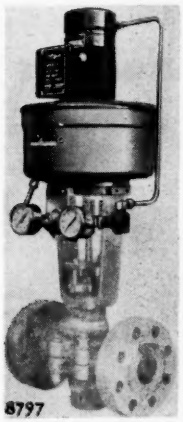
New high-pressure quick disconnect features safety; is said to be "the only unit available that can be used to safely and quickly disconnect a pressurized line, with pressures up to

3,000 psi." With handle upright as shown, an integral floating ball-seat valve is fully open. To disconnect line, handle is rotated 90° down. During this 90° movement, valve closes and, simultaneously, pressure downstream from valve seal is automatically bled out. Fitting at downstream end cannot be removed while valve is in open position; nor can valve be put into open position with downstream fitting disengaged. High flow factor results from unobstructed straight-thru flow path with constant cross-section area. Sizes: ¼", ⅜" and ½".—*Hydromatics, Inc., Cedar Grove, N. J.*

For more information circle **317** on inquiry card.

VALVES, etc.

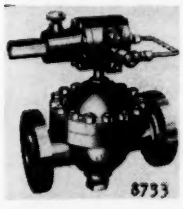
ELECTROPNEUMATIC POSITIONER



New "Model E" electropneumatic positioner, now available as an integral component of maker's "Series LB Control Valves," eliminates transmission lag inherent in an all-pneumatic system; provides valve positioning directly proportional to dc commands from control instruments. No electropneumatic transducer is required; full 100-psi plant air supply can be used. —*Conoflow Corp.*, 2100 *Arch St., Philadelphia 3, Pa.*

For more information circle **318** on inquiry card.

DIAPHRAGM RELIEF VALVE



New "Dia-Grid" pilot-operated relief valve features main valve with only one moving part —rubber diaphragm—which flexes to open or close the valve. This provides positive shut-off operation. New valve is easy to maintain; is available in 2", 4", 6" and 8" connections with flange ratings of 150, 300 and 600 psi. Relief ranges from 10 to 600 psi.—*Fisher Governor Co., Marshalltown, Iowa.*

For more information circle **319** on inquiry card.

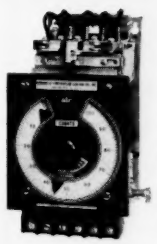
PACKLESS VALVES

New duo-seal packless pneumatic valves for converters, unit ventilators and air conditioners, etc., use a primary seal, and a spring-loaded neoprene O-ring as a secondary

for time and sequence control in automatic machinery . . .

atc®

BUILDING BLOCKS for MACHINE AUTOMATION

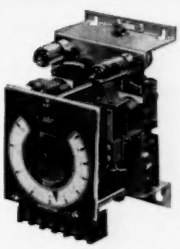


STOP CYCLE DIAL TIMERS

for accuracy . . . flexibility . . . instantaneous reset

Any one of 8 contact circuits are manually selected on the job by adjusting color coded slides. Split-division setting with Vernier. Rated at 25 amps, 115 volts a-c. Repeat accuracy: ½ of 1% of range. "Vernier Set"—13 ranges from 0-15 sec. to 0-60 hrs. "Cycle Progress"—10 ranges from 0-120 sec. to 0-60 hrs.

A

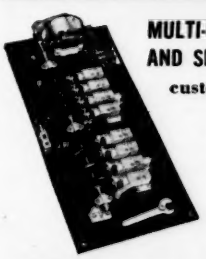


ELECTRONIC TIMERS

for intervals from .02 to 30 seconds

Direct time setting dial. Intervals unaffected by normal line voltage changes, vibration, tube age, high humidity or temperature changes from 0-100°F.

B

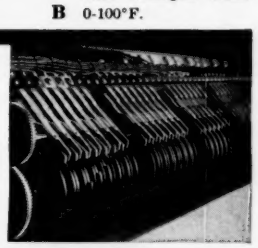


MULTI-CIRCUIT PROGRAMMERS AND SEQUENCE CONTROLS

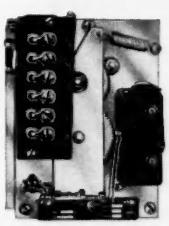
custom built from standard parts

Positive snap action. Completely flexible. Easily and quickly adjusted. Rated at 15 amps, 115 volts, a-c. Repeat accuracy: ½ of 1%.

C Pneumatic



D Electric



TIME DELAYS

positive acting . . . compact . . . instantaneous resetting

For 1 or 2 loads. Adjustable or fixed period. Rated at 10 amps, 115 volts, a-c. Factory Mutual approved. Twelve standard ranges from .75 sec. to 30 min.

E

CONTROLLERS F

for economic control of electrically heated equipment

Eliminate power loss . . . control full ON time as percentage of one-minute cycle to proportion power input to load demand. Rated at 20 amps, 115 volts, a-c. Twelve standard ranges from 0-15 sec. to 0-24 hrs.

What are your requirements?

atc®

CONTROL SYSTEMS AND COMPONENTS

AUTOMATIC TEMPERATURE CONTROL CO., INC.
Subsidiary of Safety Industries, Inc.
5224 Pulaski Avenue, Phila. 44, Pa.

Please send me literature covering:

(A) Bulletin N-11_____ (D) Bulletin N-101_____
(B) Bulletin N-91_____ (E) Bulletin J-31_____
(C) Bulletin N-20_____ (F) Bulletin M-11_____

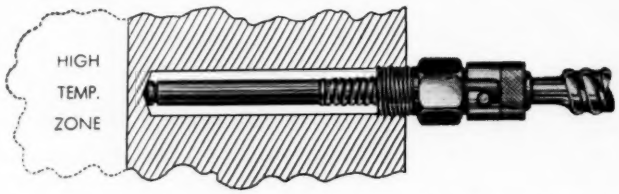
NAME_____
COMPANY_____
STREET_____
CITY_____ ZONE_____ STATE_____

IN CANADA: POWERLITE DEVICES, LTD., TORONTO, MONTREAL AND VANCOUVER
ALL OTHER FOREIGN: ATC EXPORT DEPARTMENT, 1010 SCHAFF BUILDING, PHILADELPHIA 2, PA., U.S.A.

For more information circle **121** on inquiry card.

Spring-Loaded Thermocouples Assure Dependable Contact

Field-Proven By Many Years' Successful Use



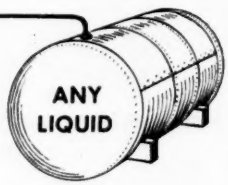
You always get fast, dependable response from T-E's miniature bayonet thermocouples because (1) spring-loaded hot junctions are always held in tight contact with the measured surface—regardless of expansion and contraction, and (2) the 'couples themselves are extremely sensitive to temperature changes. They are widely used with cylinder heads, extruders, heat transfer lines and other similar applications. Adapters of different lengths permit use of one thermocouple to measure temperatures at many different depths. Specially designed, patented, pipe-clamp adapters are also available. Bayonet-lock caps provide quick, easy removal. Lead connections are supplied straight or with 45° or 90° angles. All probes and adapters are of Stainless Steel. Available in C-C, I-C and C-A.

Write for Bulletin 2-F.

Thermo Electric Co. Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

For more information circle **122** on inquiry card.

TANK-O-METER
FOR MEASURING TANK CONTENTS
ANY DISTANCE AWAY



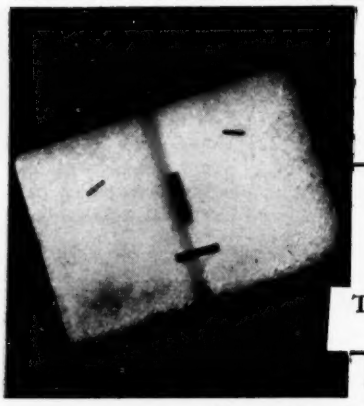
TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

For more information circle **123** on inquiry card.



WORRIED ABOUT PRECISION PIVOTS?

Call VK

Steel, chromium plated, or carbide precision pivots to .013" diameter. 1 RMS or finer surface finish. Diameter tolerances to .000010". Chamfers, radii, lapped ends, etc.

Also volume production lapping of flat or round production parts.

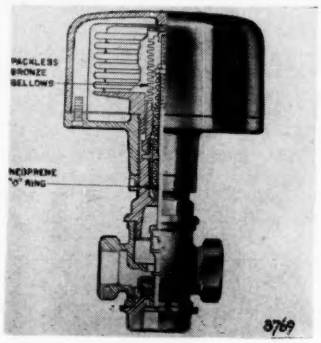
Submit your specifications

THE VAN KEUREN COMPANY
176-A WALTHAM STREET
WATERTOWN, MASS.

The photographer's nightmare at the left consists of a lump of sugar and four VK Precision Pivots. The "arms" are .080" long.

For more information circle **124** on inquiry card.

NEW INSTRUMENTS



seal. Top is easily removable so that bronze bellows can be replaced without draining water system, shutting off steam, or removing valve from line.—*Powers Regulator Co.*, 3434 *Oakton St., Skokie, Ill.*

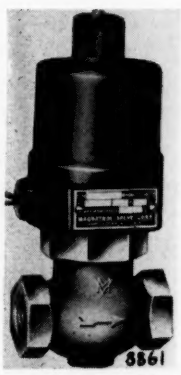
For more information circle **320** on inquiry card.

STEAM REGULATING VALVE

New "Type 44" pressure-reducing and -regulating valve for steam service, featuring built-in but easily-removed strainers for pilot and main valve, is a single-seat internal-pilot-operated piston-actuated model responsive to smallest changes in reduced pressure. Max inlet pressure 250 psi at 400°F; delivery pressures 5-250 psi. Valve is also available with external sensing line. Sizes 2", 2½", 3" and 4" with iron body and flanged ends.—*A. W. Cash Co., P.O. Box* 551, *Decatur, Ill.*

For more information circle **321** on inquiry card.

FULL PORT SOLENOID VALVE

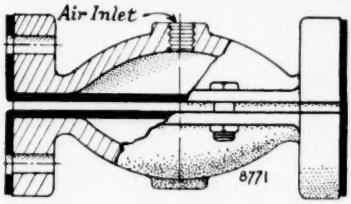


New "Type AR" normally-open solenoid valve has full-port capacity; features a completely tight shut-off when solenoid is energized; is said to be ideal also for control of vacuum lines; is available in sizes from ⅛" to 3" with pressure ratings to 300 psi. It incorporates maker's unique removable operating assembly: inspection and cleaning without disturbing either line or electrical feed (where flexible conduit is used).—*Magnatrol Valve Corp.*, 73 *Fifth Ave., Hawthorne, N. J.*

For more information circle **322** on inquiry card.

PINCH VALVES

New small-diameter series of "Microflex" valves for remote control of low rates of flow was designed spe-



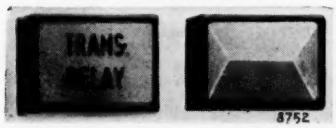
cifically for maximum flexibility. Sleeve sizes from $\frac{1}{16}$" to $\frac{1}{2}$" ID are interchangeable using same valve body. Specifying five tubes will provide extremely wide rangeability for lab, pilot plant, or process applications.—*Red Jacket Co., Inc., 500 Bell Ave., Carnegie, Pa.*

For more information circle **323** on inquiry card.

PILOT LIGHTS, etc.

INDICATING LAMPS

New rectangular indicating lights, with several improved design features, permit designation to be en-

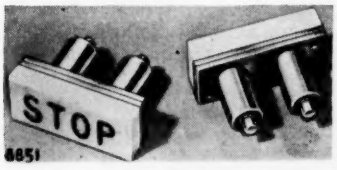


graved directly on lens, eliminating the separate name plate, improving appearance and increasing visibility. Flat or prismatic lens; all colors; two sizes: $1\frac{13}{32}$" x $\frac{31}{32}$" and $3\frac{1}{32}$" x $1\frac{1}{16}$". Lamps are single-hole mounted in a circular opening. Multiple application permits simple annuciator assembly by maker or user.—*The H. R. Kirkland Co., 8 King St., Morristown, N. J.*

For more information circle **324** on inquiry card.

PANEL INDICATOR LIGHT

New "Type L5500" twin-lamp rectangular indicator light contains abbreviations, words, or entire phrases



engraved on its $1\frac{3}{8}$" by $\frac{9}{16}$" plastic lens face. Lens face is evenly backlighted by two AN 3140 lamps easily replaced from front of panel. Use of two lamps acts as a safety check. —*Hetherington, Inc., Sharon Hill, Pa.*

For more information circle **325** on inquiry card.

NEON INDICATOR

New subminiature neon lamp assembly features built-in resistor. "NE2A" neon lamp is contained in a

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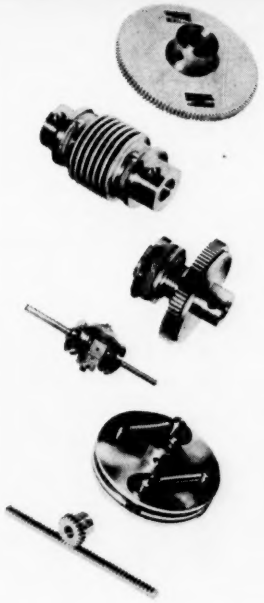

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For more information circle **125** on inquiry card.

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TO: Production Dept.
FROM: Board of Directors
RE: Production Difficulties on FN100

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*as in Fahrenheit.

The Model 6365 is a sensitive bridge type temperature controller, designed to control at set points between 0°—250° F., with adjustable differential. The bridge circuit is a separate module which can be readily replaced with other temperature range modules. For further information, write to

Autron
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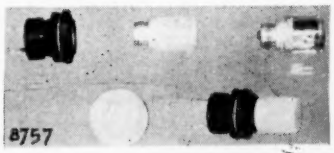
1254 WEST SIXTH STREET
LOS ANGELES 17, CALIF.

For more information circle **126** on inquiry card.

NEW INSTRUMENTS



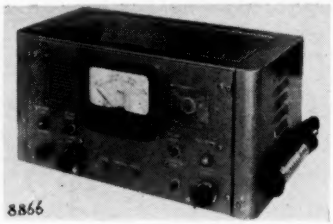
transparent plastic cap obtainable in three colors: clear, red and amber. Threaded cap easily replaced from front of panel. Built-in resistor is so designed that it does not add to overall length of unit. Construction and finish comply with most MIL specs. —*Marco Industries Co.*, 207 *S. Helena St., Anaheim, Calif.*

For more information circle **326** on inquiry card.

NUCLEONICS

AREA MONITOR

New "Nucliguard," combination area-personnel-equipment monitor, incorporates a newly-developed 3-cycle

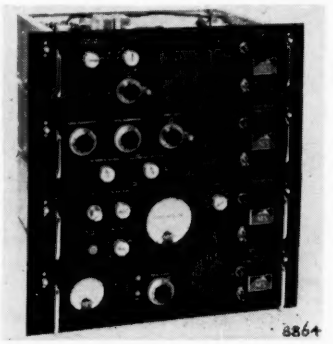


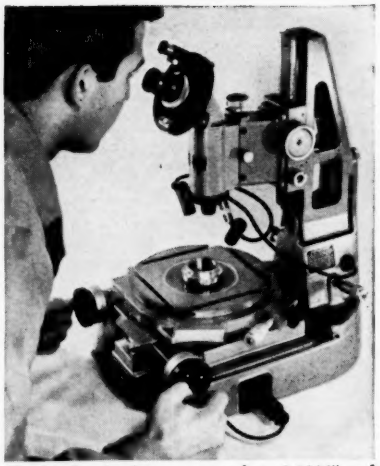
logarithmic count rate meter; is available with either a beta-gamma-sensitive GM probe, or with a gamma-sensitive scintilation probe. Any desired warning level can be preset and, when exceeded, a visual signal and an audible alarm are operated. Equipment includes a calibrated radioactive test sample, and a test signal.—*Nuclear Measurements Corp.*, 2460 *N. Arlington Ave., Indianapolis* 18, *Ind.*

For more information circle **327** on inquiry card.

ALPHA, BETA AND GAMMA SPECTROMETER

New "Model SR-300" has a number of unusual features which make it suitable for radiation measurements involving widely varying degrees of spectral selection. Energy-band width





Toolmakers' microscope reads to 0.0001" and 1 minute of arc. Co-ordinate range 4" x 2". Compact built-in rotary stage.

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Here are reliable, easy-to-use microscopes for precise, indisputable measurement of piece parts, tools, dies, thread gages, templates, jigs, fixtures, etc. With these instruments you make direct, non-destructive measurements — no contact, no distortion, images are sharp and clear.

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Write for Bulletin 161-54

The Gaertner Scientific Corporation

1211 Wrightwood Ave., Chicago 14, Ill.

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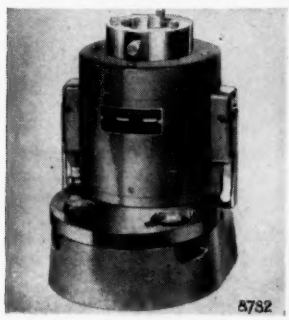
For more information circle **127** on inquiry card.

ranges from zero to full spectrum (instead of usual 0-10%) so that instrument can be used as a differential or integral spectrum scanner, as a photopeak counter or as a wide energy-band counter. Basic spectrometer consists of a linear pulse amplifier, a pulse height analyzer, a precision ratemeter and a high voltage power supply. Each has its own power supply and can be used independently in other lab applications.—*Mount Sopris Instrument Corp.*, 1320 *Pearl St., Boulder, Colo.*

For more information circle **328** on inquiry card.

LEAD SHIELD

New "Model LS-7M Lead Shield" incorporates a swing-out absorber shelf and a 3-tray sample turntable

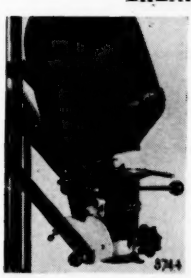


which accurately positions samples under scintillation detector crystal or phosphor. As turntable rotates, one sample can be counted while two others are being prepared and placed in trays.—*Technical Associates*, 140 *Providence Ave., Burbank, Calif.*

For more information circle **329** on inquiry card.

PHOTOGRAPHY

ENLARGER



New "Primos Junior Enlarger" allows completely automatic foolproof focusing for magnifications from 2 to 10 diameters (larger by hand). Head is lowered or raised for desired print size and then fixed in position. Head can be easily tilted back for advancing film; is strongly supported by parallelogram with spring counterbalance.—*Karl Heitz, Inc.*, 480 *Lexington Ave., New York* 17, *N. Y.*

For more information circle **330** on inquiry card.

35-mm CAMERA

New "Contina III," said to be "the most versatile model in the Contina line," embodies many refinements, including a standard lens into which component wide-angle and tele lenses can be changed. Standard lens is a Pantar f/2.8, 45mm in Prontor SVS

Using vertical polarized light on a cross-section of pipe, photographer Bernard Hoffman clearly shows the ravages of corrosive action.

Controlling Corrosion in Fluid Engineering

Corrosion seldom works alone. Together with heat, pressure and abrasion factors, it compounds the problems of fluid engineering. But when you have valve design problems involving corrosion, you can look to the engineering leadership available at S. Morgan Smith for assistance.

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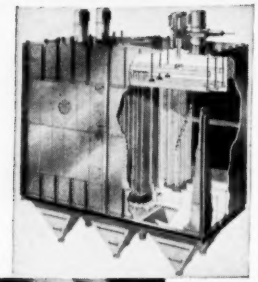
For more information circle **128** on inquiry card.

LARGE DESIGNS?



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For more information circle **103** on inquiry card.

NEW INSTRUMENTS

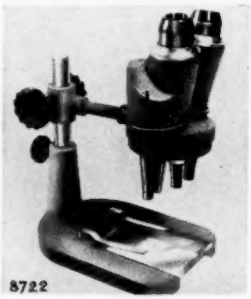
shutter with delayed action and speeds to 1/300th sec. Front element can be replaced with either a Pantar f/4, 30mm wide-angle or Pantar f/4, 75mm tele component lens, both bayonet-mounted. Various accessories are available.—*Carl Zeiss, Inc.*, 485 *Fifth Ave., New York* 17, *N. Y.*

For more information circle **331** on inquiry card.

MISCELLANEOUS

STEREO MICROSCOPE

New low-cost (under $100) American-made stero microscope with up to 3" working distance gives an erect,

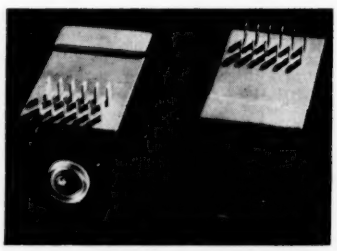


clear sharp image. Two sets of objectives on a rotating turret. Standard pair of wide-field 8× Kellner eyepieces gives 21× and 34× (other eyepieces available). Prism erecting system low-reflection coated. Helical rack and pinion focusing with large control knob for fine adjustment. Interpupillary distance adjustable.—*Edmund Scientific Co., Barrington* 17, *N. J.*

For more information circle **332** on inquiry card.

STATIC SWITCHING UNIT

New plug-in encapsulated static control unit broadens scope of static switching to include protective func-



tions such as undervoltage protection, undervoltage release, switch volts protection, overvoltage limit, fault indication, etc. It provides protective functions by means of three electrically-isolated control windings (one of which is suitable for use in circuits up to 750 vdc) on a magnetic amplifier. Unit has a monitor light which indicates whether or not unit is in operation.—*General Electric Industry Control Dept., Roanoke, Va.*

For more information circle **333** on inquiry card.

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CORRECTION

Insulation Tester (Peschel Electronics Inc.), February issue, page 324, fifth line from bottom should read:

"small test current (10 microamp) . . ."

CORROSION METER

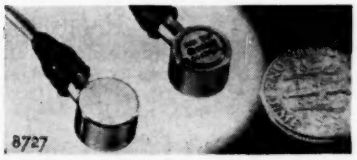
New "Corro-Dex" single-knob-control battery-operated corrosion tester (Pure Oil Co design) weighing 9 lb

ca be used in field or in lab; measures corrosion as low as 0.000001"; utilizes same probes as those used on standard line-operated unit. Probes are available for long or short tests, normal temperature and pressure conditions, high pressures, or high temperatures, or combinations.—*Labline, Inc., 3070-82 W. Grand Ave., Chicago 22, Ill.*

For more information circle **334** on inquiry card.

TURBULENCE PICKUP

New "Turbulence Gage," designed to measure turbulent pressures in wind tunnels, along skin surfaces of



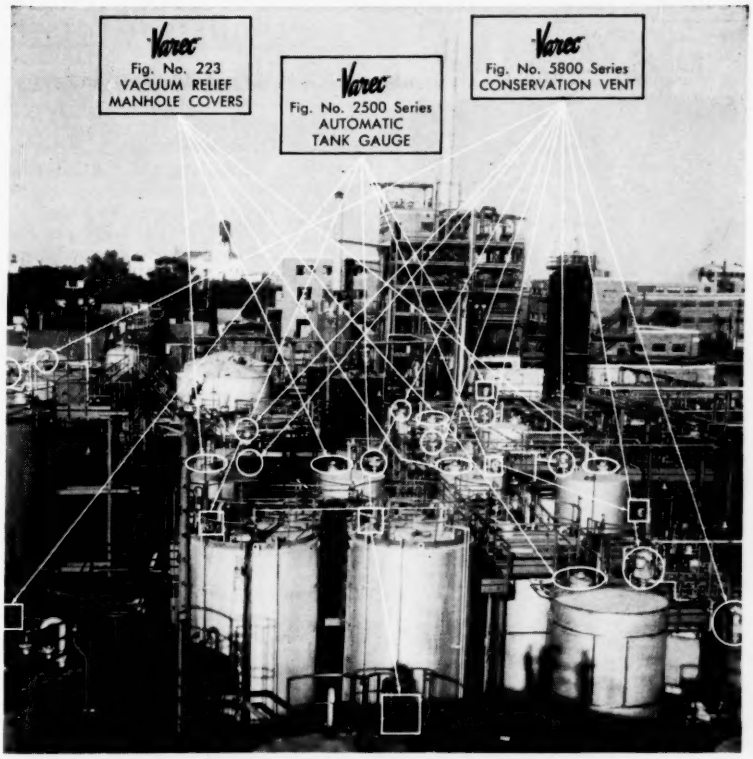
models, for study of fluid flow, etc., provides sensitivity of 40 mv/psi; has pressure range of 0-10 psi; natural frequency above 50 kc, frequency variation 5% from 2 cps to 10,000 cps. —*Endevco Corp., 161 East California St., Pasadena, Calif.*

For more information circle **335** on inquiry card.

PICKUP CONTROL UNITS

New "Model 4901-RAC" 115-vac-type of proximity pickup control unit has been redesigned to utilize a stand-

ard electrical plug rather than a microphone connector at output; operates with "4900 Series" of standard proximity pickups which utilize a principle similar to that of a mine de-



Photo—Courtesy of Barrett Division—Allied Chemical and Dye Corporation

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A glance at the above photo of the Philadelphia plant of the Barrett Division of the Allied Chemical & Dye Corporation reveals dozens of storage tanks equipped with "Varec" Conservation Vent Units, Pressure and Vacuum Relief Manhole Covers, and Automatic Tank Gauges.

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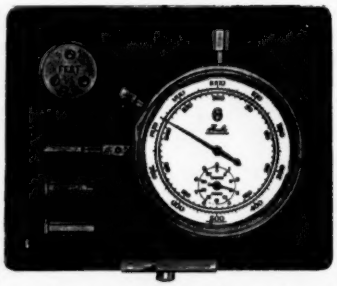
For more information circle **131** on inquiry card.

HASLER SPEED INDICATOR



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For more information circle **133** on inquiry card.

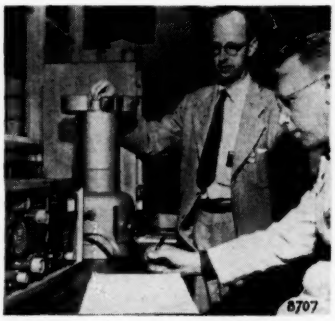
NEW INSTRUMENTS

tector wherein metal coming near pickup can be used to control circuits, machines, counters, etc. ★New "Model 4901-AN" control unit, likewise for use with proximity pickups, provides dc pulses for actuating counters, recording devices, 'scopes and dc voltmeters.—*Electro Products Labs., Inc., 4500 N. Ravenswood Ave., Chicago 40, Ill.*

For more information circle **336** on inquiry card.

LEAK DETECTION SYSTEM

New "Radiflo" non-destructive leak-detection system utilizes an inert non-toxic gas; can be used for positive or

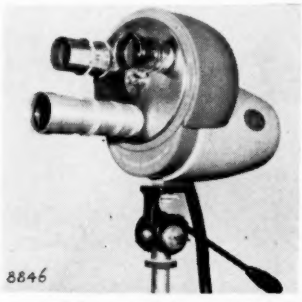


negative sealed pressures; is said to be "the only system that lends itself to mass production since it permits tests of sealed units in large quantities with extremely low labor cost per unit." No pinch-off tubes are needed; products are tested after they are completely sealed.—*American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.*

For more information circle **337** on inquiry card.

REMOTE CONTROL TURRET ITV CAMERA

New 3-lens turret for maker's industrial and institutional TV camera



is power-driven and is operated from a remote control box.—*General Precision Lab., Inc., Pleasantville, N. Y.*

For more information circle **338** on inquiry card.

EMERGENCY LIGHTING SYSTEM

New centralized emergency lighting system that constantly supervises itself is listed by Underwriters Laboratories, also exceeds requirements of National Electrical Code. It not only

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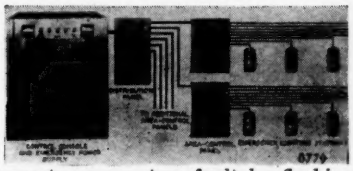
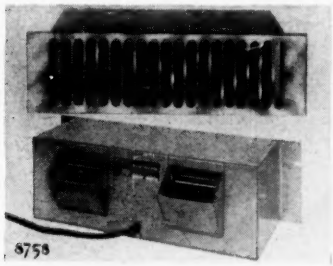


reports any system fault by flashing lights and buzzers, but even sounds an alarm when an emergency lamp is removed from its socket; is 100% foolproof.—*Standard Electric Time Co., Springfield 2, Mass.*

For more information circle **339** on inquiry card.

RACK COOLING FAN

New "Model 2B300," designed to fit 5¼" panel heights in standard 19" racks (and also 24" or special racks),

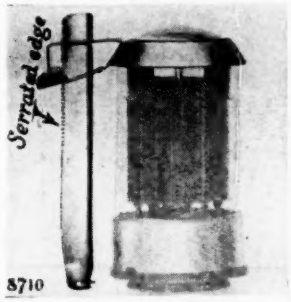


features two unique blower wheels delivering 150 cfm with quiet operation; stainless steel grilles; permanent type filters; 50-watt motor (115-v 60-cps standard, 400-cps and dc motors available).—*McLean Engineering Laboratories, P. O. Box* 228, *Princeton, N. J.*

For more information circle **340** on inquiry card.

COMPONENT RETAINERS

New "Top-Tainers," stainless-steel top-holding electron tube and component retainers designed to conform



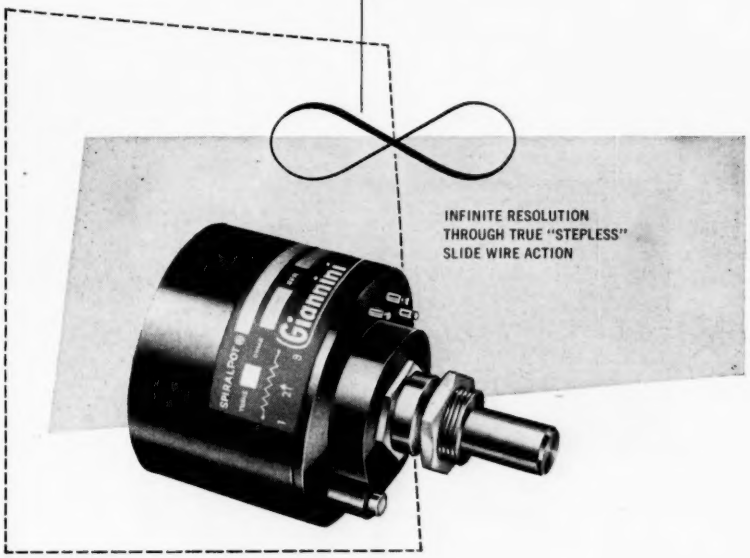
with military approved method of tube retention, consist of a post and a cap; are available in single- and double-post styles to hold components from ⅞" to $2\frac{5}{16}$" dia. Post heights ⅞" to 5½" in increments of ⅛". "Top-Tainers" hold tubes and components securely in place under severe shock and vibration, yet can be removed with a slight upward pressure on locking tab.—*The Birtcher Corp., Industrial Div.,* 4371 *Valley Blvd., Los Angeles* 32, *Calif.*

For more information circle **341** on inquiry card.

INFINITE RESOLUTION SPIRALPOT®

IMMEDIATE DELIVERY

± 0.1% Linearity | **10 TURNS** | **1,000 OHMS**



Quantity production now makes the popular 10 turn 1000 ohm Model 85175 Spiralpot available for immediate delivery.

Designed to eliminate hunting in sensitive servo systems, the Spiralpot finds many applications where infinite resolution and precise linearity are required. Only 1.5 inches in length and 1.5 inches in diameter, this rugged instrument mounts identical to wire-wound types and can be used as a direct replacement in many cases. Low inductance and capacitance effects make it ideal for AC as well as DC applications.

Standard 85175 Spiralpots are available in three or ten turn models with resistance ranges from 50 to 250 ohms per turn. For special applications, the unit can be supplied with resistance ranges as low as two ohms per turn and linearity to ±0.05%. Other Spiralpot models are available with synchro mounting, in resistance ranges to 625 ohms per turn, and for use at elevated temperatures.

For complete information on these versatile infinite resolution potentiometers, write for Spiralpot Bulletins.

See you at the I.R.E. Show, N. Y. Coliseum Booths 3509 – 11 and 13

Giannini *NEW JERSEY DIVISION*

G. M. GIANNINI & CO., INC. • PASADENA, CALIFORNIA

For more information circle **136** on inquiry card.

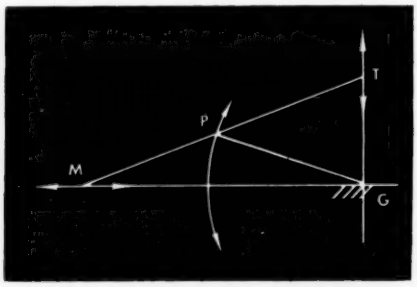
INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Rectilinear Recorder

The "recti/riter" is the first galvanometer-actuated recorder with true straight-line motion. Its exclusive "recti/rite" system inscribes a signal in its true shape on a rectilinear chart in a form that can be measured with a ruler . . .

The "recti/rite" system is an error-free linkage arrangement that satisfies basic trigonometry in changing curvilinear motion to true rectilinear motion. "MT" represents the writing pen; "T" the pen point; "PG" the swinging galvanometer metering arm; and "G" the fixed pivot of the meter movement. Then, if "PM", "PT", and "PG"



are equal, "M", "T", and "G" would always be points on the circumference of a circle whose center is at pivot point "P". If, in addition, "M" is limited to fore-and-aft motion along line "MG", then "T" will always have linear motion perpendicular to line "MG". In the "recti/rite" system, PG/PM=PM/PT . . . (*From new 6-page Bulletin R-501, Houston Technical Laboratories, 3701 Buffalo Speedway, Houston 6, Texas.*)

For this literature circle **401** on inquiry card.

Tape Recorder/Reproducer

FR-100 recorder/reproducers are available with as many as 14 tracks. With interchangeable plug-in amplifiers, each of these can be used with any of three recording techniques. More than one hundred useful combinations are possible—and over one thousand channels of simultaneously occurring data can be accommodated on one tape using currently available multiplexing equipment.

Table shows optimum balance between frequency response and tape speed . . . Data recorded at 60 ips and reproduced at 1⅞ ips are stretched out 32-to-1.

Extremely diverse data combinations are easily handled.

Speed	Frequency	Recording Time
60 ips	100 to 100,000 cps	8 or 12 minutes
30 ips	50 to 50,000 cps	16 or 24 minutes
15 ips	50 to 25,000 cps	32 or 48 minutes
7½ ips	50 to 12,500 cps	64 or 96 minutes
3¾ ips	50 to 6,250 cps	2 hrs 8 min or 3 hrs
1⅞ ips	50 to 3,125 cps	4 hrs 16 min or 6 hrs

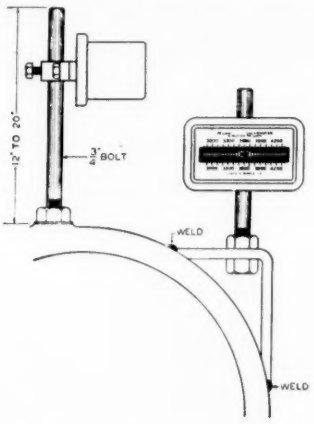
Consider, for example, the requirements of a comprehensive test run on a jet engine. With *direct record amplifiers*, any of the extremely high frequencies associated with jet exhaust are easily within range. With *FM record amplifiers* any vibrations of mechanical parts of supporting structure can be recorded with transient amplitudes accurately retained. By *multiplexing and recording through direct or PWM amplifiers*, slowly changing data such as temperatures, pressures, fuel flows, and positions of valves and controls can be accommodated in large quantities on a few tape tracks . . . (*From new 20-page Booklet FR-100, Ampex Instrumentation Div., 934 Charter St., Redwood City, Calif.*)

For this literature circle **402** on inquiry card.

Resonant Reed Tachometers

Resonance is that quality of an elastic body which causes it to vibrate vigorously when subjected to small, rhythmic impulses at a rate equal or nearly equal to its natural frequency . . . .

The Frahm Resonant Reed Tachometer consists of a set of consecutively tuned steel reeds mounted in a case



with a scale to indicate rpm or vpm of the reed or reeds as they come to motion . . . .

The slightest vibration of a machine is enough to actuate the tuned reeds which respond by resonance, and ordinarily there is no difficulty in finding a convenient location on the machine where the tachometer will indicate satisfactorily.

Occasionally, however, a rotor is so well balanced that vibration is almost imperceptible—ideal for the machine, but not for the Frahm tachometer which depends on a *little* vibration.

This problem has been met by what we call a resonant mounting for the tachometer. The principle is that of a weight adjustably mounted on an arm (an iron rod or bolt) attached to the machine. Using the tachometer as the weight, and with a suitable bracket, the instrument is adjusted up or down the rod to a point where the reeds come into vibration . . . (*From new 16-page Bulletin 31, James G. Biddle Co. 1316 Arch St. Phila. 7, Pa.*)

For this literature circle **403** on inquiry card.

GET OFF
the shopping merry-go-round

If you have a limited budget,

INVEST IN THIS HATHAWAY BASIC SYSTEM

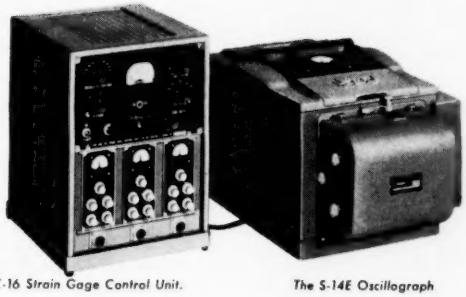
You get *more* beneficial features from this integrated dynamic analysis system.

The MRC-16 Strain Gage Control Unit

Offers a choice of two amplifier elements—carrier channel to 1500 cps or ac channel to 6000 cps . . .
Provides multi-purpose meter indication of static strain, gage balance and carrier voltage . . .
Supplies regulated plate voltage to oscillator and amplifier elements from 115 volt, 60 cycle . . .
The calibration of any or all channels is extremely convenient, accurate to one-half of 1% . . .
Weighs only 50 pounds—15 x 12 x 16 inches.

The S-14E Oscillograph—

Records up to 24 channels using OV type multi-element galvanometers . . .
Clearer records assured by use of automatic lamp brilliance control . . .
Offers 8 easily selected chart speeds—1/10 to 40 in/sec . . .
Accommodates 6-inch record up to 300 feet long . . .
Provides time coordinates ranging from 1/100 to 10 seconds . . .
Weighs only 60 pounds—12 x 12 x 24 inches.
In addition, optional accessories may be purchased as recording needs demand.



The MRC-16 Strain Gage Control Unit. *The S-14E Oscillograph*

More detailed specifications can help prove to you these two Hathaway units are your best possible investment.

Write for Bulletins 4-6H and 1-4H.

Purchase the finest quality

with a minimum investment

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HAMILTON WATCH COMPANY

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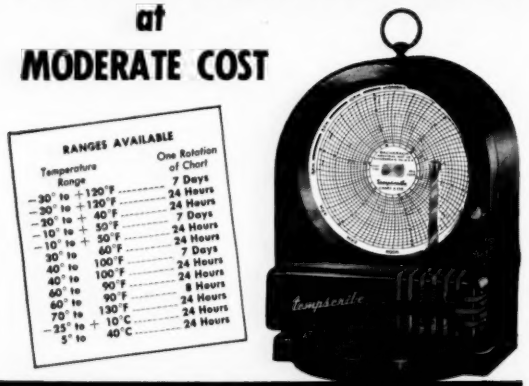
For more information circle **137** on inquiry card.

For Accurate TEMPERATURE RECORDS at MODERATE COST


RANGES AVAILABLE
Temperature Range
One Rotation of Chart
−30° to +120°F ..... 7 Days
−30° to +120°F ..... 24 Hours
−20° to + 40°F ..... 24 Hours
−10° to + 50°F ..... 7 Days
−10° to + 50°F ..... 24 Hours
30° to 60°F ..... 24 Hours
40° to 100°F ..... 7 Days
40° to 100°F ..... 24 Hours
60° to 90°F ..... 24 Hours
60° to 90°F ..... 8 Hours
60° to 130°F ..... 24 Hours
70° to 130°F ..... 24 Hours
−25° to + 10°C ..... 24 Hours
5° to 40°C ..... 24 Hours
tempscribe

Use TEMPSCRIBE Recorders

The TEMPSCRIBE self-registering Recording Thermometer meets a long-felt need for a moderately priced recorder for general purpose applications where a graphic record of temperature in surrounding air is required. The record—written on an easy-to-read chart, 4" in diameter, with graduations spaced uniformly over full range—is indispensable wherever knowledge is desired if temperature goes above or below any given point. TEMPSCRIBE is the only recorder made with pen and actuating element in door, which, when opened, permits a clear view of the complete chart, and easy chart replacement without danger of damaging pen arm or accidentally marking chart.

Write for Bulletin 704

BACHARACH INDUSTRIAL INSTRUMENT CO.

200 N. Braddock Ave. • Pittsburgh 8, Pa. T-13r

For more information circle **138** on inquiry card.

A NEW DIMENSION IN DESIGN MATERIAL...

PRECISION BORE GLASS TUBING

Wilmad Offers Unheard-Of Accuracy and Low Cost

Design Engineers are constantly searching for new materials to reduce costs and improve preformance. Wilmad has helped make glass a "new" material by producing precision bore tubing of uniform accuracy with amazing tolerance limits. Wilmad Precision Bore Tubing can be used in making product components, instrument assemblies or sub-assemblies, wave guide tubes, manometers, rotameters, viscosimeters, barometers, McLeod gauges, dilatometers, burettes, dash pots, capacitors, diodes . . in virtually hundreds of precision applications in industry.

Learn how precision bore glass tubing can improve **your** product. Let our engineers help you determine how Wilmad Glass Tubing can solve your design problems.

Write for our **new** bulletin on Precision Bore Tubing.

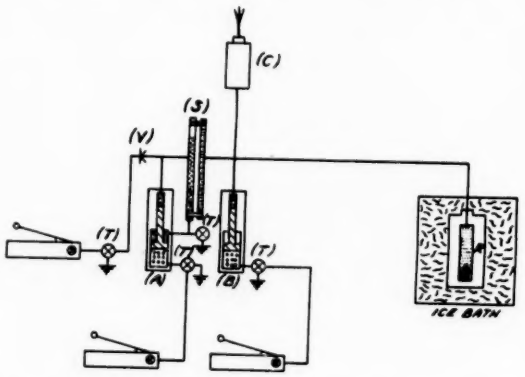
WILMAD GLASS CO., INC.

Landisville, New Jersey

For more information circle **139** on inquiry card.

High Pressure Intensifiers

The freezing point of mercury at 7640 kilograms per square centimer and 0° Centigrade is to the pressure scale what the boiling point of water is to the temperature scale. The change of mercury from the liquid to the solid phase is accompanied by a decrease in volume and by a dramatic change in electrical resistance. Nobel



Prize winner Dr. P. W. Bridgman was first to isolate and evaluate the freezing point of mercury.

The use of Harwood equipment to detect the mercury freezing point by observing the volume change is illustrated . . .

The upper side of the low pressure cavity of intensifier "A"—normally vented to atmosphere—is filled with a liquid and connected to a sight glass "S" to indicate the piston displacement and, therefore, the changes in volume. The sight glass has a ⅛" diameter bore so the displace-

Chip-proof PLASTIC LEGEND PLATES

engraved in your own plant

Tough **GRAVOFLEX** blanks are laminated in sharp contrast colors. No need to keep large inventory—all sizes, varied colors available on short notice. Low-cost GRAVOFLEX legend plates stand *up* better, stand *out* better!

Use the portable **ENGRAVOGRAPH** to mark legend plates to your specifications, on the spot, when you need them—with unskilled labor, because it's tracer-guided. Big savings on short runs and "one-shot" jobs. Eliminates costly delays. Over 17,000 in use.

See demonstration at
BOOTH #1234
I. R. E. SHOW

Send for Booklet XL-1 and sample plate.

neur hermes ENGRAVING MACHINE CORP.
13-19 UNIVERSITY PLACE, NEW YORK 3, N. Y.

ment in the sight glass column is 360 times that of the piston . . . The system is charged to about 10,000 psi by means of a hand pump. The use of the Harwood check and throttle valves makes it possible to make multiple strokes of the intensifiers while holding pressure in the system and to bleed pressure to ground at a regulated rate. The piston of intensifier "B" is then advanced to the end of its stroke, raising the pressure to about 90,000 psi. During the remainder of the experiment the pressure is raised by advancing the piston of intensifier "A". Using this arrangement small volume changes in the mercury are easily detected . . . (*From new 30-page Booklet "High Pressure Intensifiers and Pumps," Harwood Engineering Co., Inc., South St. Walpole, Mass., which also contains "Stress & Strain Tables."*)

For this literature circle **404** on inquiry card.

LIRA Infrared Analyzers

Two similar Nichrome filaments are used as sources of infrared radiation. Beams from these filaments travel through parallel stainless steel cells. One beam traverses the sample cell and the other the comparison cell. The

GENERAL SPECIFICATIONS LIRA

	MODEL 100	MODEL 200
PRINCIPLE OF OPERATION	Analysis unit to be interrupted type non-dispersive infrared analyzer with dual infrared sources and single pneumatic detector-receiver. Operates on principle of electrical null-balance feedback by varying voltage on one infrared source	Analysis unit to be interrupted type non-dispersive infrared analyzer with dual infrared sources and single pneumatic detector-receiver. Operates on principle of direct deflection
SPEED OF RESPONSE	90% of final reading in 20 seconds	90% of final reading in 5 seconds
NOISE LEVEL	Less than 1% of full scale	Less than 1% of full scale
ZERO DRIFT	Less than 1% of full scale in 24 hours	Less than 1% of full scale in 24 hours
ACCURACY	± 1% of full scale	± 1% of full scale
TEMPERATURE EFFECT	Accuracy of analyzer to be maintained over temperature range of -20° to 120°F	Accuracy of analyzer to be maintained over temperature range of -20° to 120°F

THE MARK OF QUALITY

BARBER COLMAN

Small Motors

"This motor assures precision timing of our new Massa Recorder"

Ernest A. Massa, Massa Laboratories, Inc.

The Massa Recorder is a new instrument which makes accurate ink records of high-speed electrical signals on a moving paper chart. To realize the full wide-range recording capabilities of the Recorder, Massa Laboratories chose a Barber-Colman YAJ Synchronous Motor which assures high-precision timing and permits compact design. For accurate actuation of your products, too, there's a wide selection of Barber-Colman small motors up to 1/20 hp. Unidirectional, synchronous, and reversible . . . with or without gearing . . . open or enclosed. Write for catalog F-4271-6.

BARBER-COLMAN COMPANY

Dept. O, 1215 Rock Street, Rockford, Illinois

For more information circle **140** on inquiry card.

FOR TESTING FABRICS THAT MUST HOLD GAS

The Cambridge Fabric Permeameter is an accurate, rugged and convenient instrument for production testing of the permeability of fabrics which are to be inflated with Hydrogen, Helium, Carbon Dioxide, etc.

The rate of permeation through the fabric is quickly determined by equipment utilizing the thermal conductivity method and is indicated in terms of liters per square meter per 24 hours of the retained gas.

Manufacturers of fabrics for lighter-than-air Craft, Life Rafts, Life Jackets, Gas Masks, etc., will find this an indispensable instrument. Send for particulars.

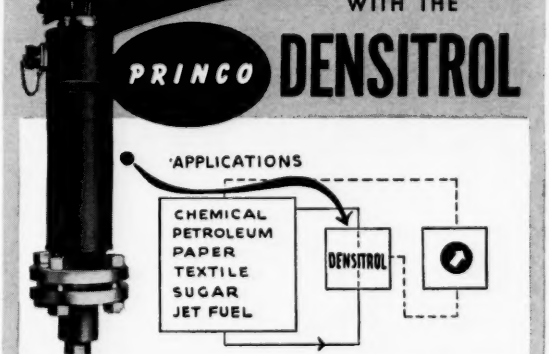
CAMBRIDGE INSTRUMENT CO., INC.

3526 Grand Terminal, New York, N.Y.

CAMBRIDGE FABRIC PERMEAMETER

For more information circle **141** on inquiry card.

GET *automatic* LIQUID DENSITY CONTROL WITH THE PRINCO DENSITROL



The DENSITROL is an extremely accurate, sensitive instrument for continuously, accurately and automatically controlling or recording the blending, mixing, separation, dilution or concentration of industrial process liquids. It quickly pays for itself because it eliminates operator attendance and does on a continuous basis what formerly was done on a batch basis.

For ranges, calibrations and other specifications, write, wire or call.

PRECISION THERMOMETER & INSTRUMENT CO.

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For more information circle **142** on inquiry card.

The New SCHERR
MICRO-PROJECTOR
with the
VERTICAL design

NEW
1957
SELF CONTAINED
IMPROVED MODEL
FEATURING

- ✓RIGID FLOOR BASE - ELIMINATING EXTRA CHARGE FOR TABLE
- ✓TILTING STAGE FOR HELIX, ANGLES AND BEVELS
- ✓4" DIA. STAGE OPENING
- ✓COLUMN SLIDE ADJUSTABLE FOR WEAR BY MEANS OF GIBS - WILL HOLD SQUARE INDEFINITELY.
- ✓CUSTOM MADE PRECISION COATED LENSES & DOUBLE CONDENSERS FOR DIFFERENT OBJECTIVES 10 TO 100X MAGNIFICATION.
- ✓AN ENTIRELY NEW PRACTICAL DESIGNED TOOL FOR INSPECTION DEPARTMENT AND PRODUCTION SHOP.

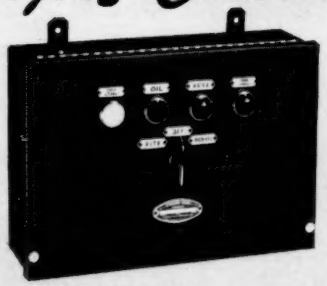
BASIC PRICE
$ 375.00

WRITE FOR ILLUSTRATED FOLDER

GEO. SCHERR CO., Inc.
COMPLETE LINE OF PRECISION INSTRUMENTS
200-MG LAFAYETTE STREET • NEW YORK 12, N.Y.

For more information circle **143** on inquiry card.

FULL AUTOMATIC
Engine Controls



Model
1436M4

SYNCHRO-START Engine Controls provide automatic start and stop from any type of remote pilot switch. Interrupted cranking periods with total time limit of cranking is a regular feature.

Standard Controls are available which provide **FULL PROTECTION** for the engine. The model shown will light an individual signal and operate an external alarm in event the engine fails to start. Should low oil pressure, high water temperature, and overspeeding occur while running, the engine will stop and Visual Signal will indicate source of trouble.

Additional safety features can be incorporated on special order.

These controls can be used with Diesel, Gasoline, and Gas engines.

Request Bulletin 501

Synchro-Start Products Inc.
8151 N. RIDGEWAY AVE. • SKOKIE, ILL.

For more information circle **144** on inquiry card.

Briefs—CONTINUED

emergent radiation is converged into the single detector cell by a beam combiner. As the gas in the detector absorbs radiation its temperature and pressure increase. An expansion of the detector gas causes a condenser microphone membrane to move. This movement, when converted and electrically amplified, produces an output signal. (*From new 8-page Bulletin* 1705-2, *Mine Safety Appliances Co.,* 201 *N. Braddock Ave., Pittsburgh* 8, *Pa.*)

For this literature circle **405** on inquiry card.

Grounding Shielded Cable

Coaxial and shielded cables are effective in electronic circuits only when properly grounded. Poorly made grounds, or grounds which in a short time become open

Six Methods of Installing Ground Leads on Shielded Cable

Method	Installation time, min per conductor				Advantages	Disadvantages
	Shielded cable		Coaxial cable			
	One end	Two ends	One end	Two ends		
1. Braid used as ground.	2.30	4.50	2.30	4.50	No soldering or crimping required. Can be done by an inexperienced operator.	Too bulky for close quarters. Difficult to terminate end of braid by either soldering or crimping.
2. Shielding used as ground	1.00	1.90			Fast operation with an inexperienced operator. No solder or crimping required.	Too bulky for close quarters. Difficult to terminate end of braid by either soldering or crimping.

circuits, result in emission of energy to nearby conductors, pickup of stray signals, power loss due to the change in impedance of the line, and reflections . . . .

Space has become so critical in electronic devices, particularly those intended for airborne use, that the bulky joints resulting from soldering a pigtail to the shielding can not be tolerated. The use of crimped ferrules only a few mils larger than the diameter of the conductor itself has proved to be a satisfactory solution . . . . (*From recent 20-page Technical News Letter, Burndy, Omaton Div., Norwalk, Conn.*)

For this literature circle **406** on inquiry card.

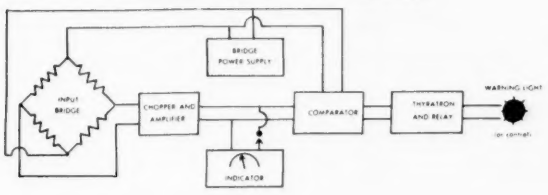
For more information circle **145** on inquiry card.

Warning Systems

The Model 401RB Warning System was developed for the purpose of monitoring static and dynamic signals from the output of strain gages located at critical structural points on an airplane . . . .

The output of each strain gage bridge is connected to a 400-cps chopper for voltage amplification by an a-c amplifier. The output of the amplifier is fed to the input of a voltage comparator. The voltage comparator generates a pulse when the input voltage equals or exceeds the preset level at which the comparator is set to fire. A reference voltage is supplied to the comparator from the strain-gage bridge power supply so that the comparator firing point is determined by output due to strain only, and is not affected by variations in bridge voltage, over a wide range. The comparator pulse then fires a thyratron, which in turn energizes a relay which connects power to the warning light. (*From new folder containing six 2-page technical bulletins, Fairchild Electrotechnics Div. of Fairchild Engine and Airplane Corp.*, 118 *East 16th St., Costa Mesa, Calif.*

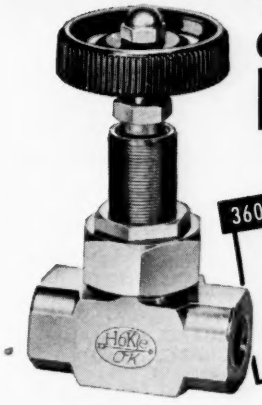
WARNING SYSTEM WITH BRIDGE INPUT



For this literature circle **407** on inquiry card.

HOKE announces

10 valves in 1



360 SERIES
High Pressure UNION BONNET GLOBE VALVE

For conditions ranging from 3000 psi to low vacuums, or distilled water to corrosive fluids. Series consists of four basic stainless steel bar stock valves . . . O-ring or Teflon packing with flat Teflon disc or vee point non-rotating, replaceable stem plug . . . plus six body styles. All parts interchangeable as well as replaceable. Choice of ¼", ⅜" or ½" pipe sizes or Swagelock tube fittings. Panel mounting, too. **Get the facts about this "10 in 1" valve. Write us today.**

HOKE

HOKE INCORPORATED
Fluid Control Specialists
231 S. Dean Street
Englewood, N. J.

For more information circle **147** on inquiry card.

Petrometer
SERIES 1400
LIQUID DEPTH GAUGES

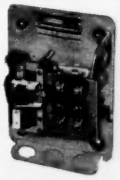
ACCURATE and EASY TO INSTALL

Available in 4 Models, Petrometer Series 1400 Tank Gauges operate on the sound principle of hydrostatic pressure. No moving parts, no expensive electrical or electronic equipment. Large vertical scale gives accurate, easy-to-see reading. And construction features make installation easy.

For complete information send for Bulletin 6004

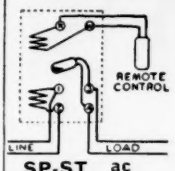
Petrometer CORPORATION
43-22 TENTH ST., LONG ISLAND CITY 1, N. Y.

For more information circle **146** on inquiry card.

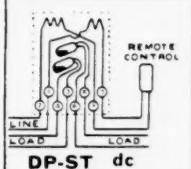


MERCOID®
MERCURY SWITCH
RELAYS
FOR VOLTAGES TO 440 ac or dc

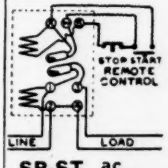
NO SPRINGS OR CLAPPERS
NO WELDING OF CONTACTS



SP-ST ac



DP-ST dc



SP-ST ac start-stop

The operation of a Mercoid Transformer-Relay has several advantages over clapper type relays. In principle, it is a low voltage transformer—the two coils of which, operate as a repulsion relay.

The primary coil is fixed in position and connected across the high voltage line. The secondary coil is movable and is connected to the control circuit.

When the control circuit is closed, the secondary coil instantly moves upward by repulsion action, thereby operating the hermetically sealed mercury contact. When the control circuit opens, the secondary coil drops by gravity restoring the mercury contact to its original position.

Hundreds of circuit arrangements are available—a few typical examples are shown

WRITE FOR BULLETIN NO. 31

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

For more information circle **148** on inquiry card.

OPTICS

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368 — 3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITINATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COPPER
*CORNING 707
*CORNING 7052
FERRITE
FERROX
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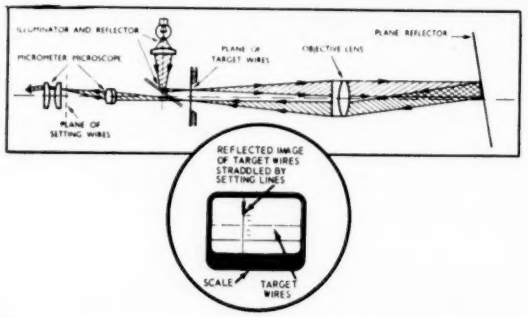
For more information circle **149** on inquiry card.

Alignment Testing

The fact that light travels in a straight line forms an attractive basis for the use of optical methods in the measurement of alignments . . . . In a perfectly homogeneous atmosphere the statement can be regarded as perfectly true, but under ordinary working conditions, where the light has to pass through air of possibly varying temperatures and densities, some qualification is needed . . .

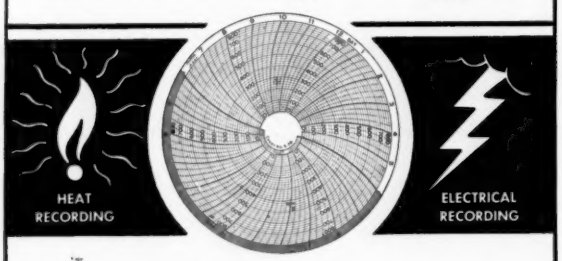
The auto-collimator is a combined collimator (an instrument for projecting parallel light) and telescope for observing that light after reflection at a plane surface. Referring to the figure which shows the optical system of one

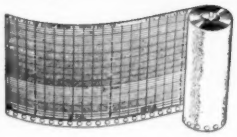


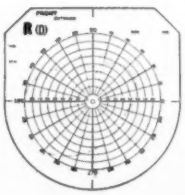
form of instrument, it will be seen that a small lamp and condenser lens constitute a source from which light, reflected into the optical axis by a thin transparent reflector, is used to illuminate target wires—fine platinum wires crossing at right angles and placed in the principal focus of the objective lens. (*From new 8-page Reprint "Alignment Testing," Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.*)

For this literature circle **408** on inquiry card.

CHARTS of all types







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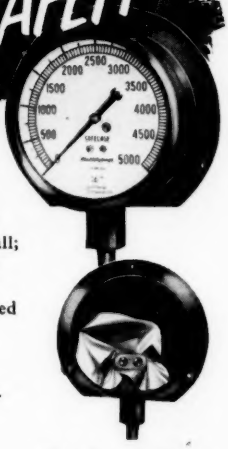

Another Marsh development... new "SAFE-CASE" gauge for those conditions where over-pressures of explosive force can occur.

Face well protected by solid metal wall; but, still more important, *entire back* is thin metal plate that opens out to exhaust any abnormal pressure.
In testing, heavy blank cartridges, fired within back of case, did not even break crystal.
Use "Safecase" for your toughest services. It is standard in Marsh "Mastergauge"—the highest development in pressure gauges.
Ask for facts.

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Test Proves Safety
Explosive force of cartridge merely opens out safety-release back. Back is firmly attached to case and cannot be dislodged during a pressure blow-out.

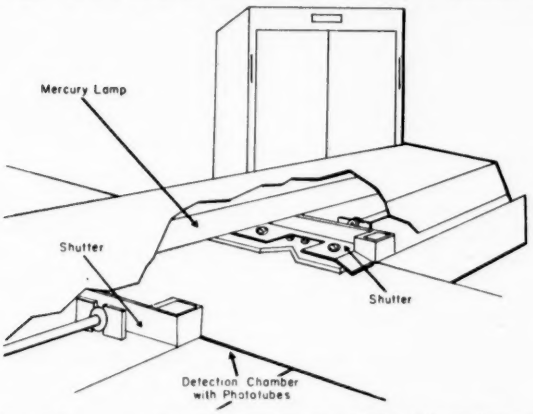
MARSH GAUGES

For more information circle **150** on inquiry card.

Pinhole Detector

The new G-E pinhole detector consists of two basic elements: the scanning head and the control panel. The scanning head, through which the strip travels, has three principal parts: (1) the light source, (2) the detection chamber, and (3) the shutters . . . .

The strip to be inspected is guided by rollers between the light source and the detection chamber; the shutter is used to prevent stray light from getting around the edges of the strip to the phototubes. When a pinhole on



the strip passes through the detector, light shines through the hole into the detection chamber causing the phototubes to emit a signal, which when amplified in the control panel can be used to sound an alarm. (*From new 4-page Bulletin GEA-6520, General Electric, Specialty Control Dept., Waynesboro, Va.*)

For this literature circle **409** on inquiry card.

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A complete "package". Unit includes all necessary connector tubing and fittings, mounting screws, fluid, instructions.

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- **Free from continuously moving parts—except for chart drive**
- **Low in cost**

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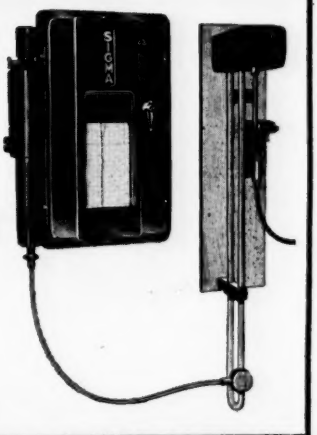

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DOUBLE RANGE, 0-16.1 & 0-80.5 M.V.

MANUAL COMPENSATOR, RANGE, 0-1 & 0-5 M.V.

REFERENCE JUNCTION COMPENSATION SET ON MAIN SCALE TO MAIN SCALE ACCURACY.

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ACCURACY ±.01MV ON LOW & ±.05MV ON HIGH RANGE

Write For Bulletin E-18

For more information circle **153** on inquiry card.

Unique design of the two-dimensional Model D-2 features—Single micrometer adjustment controls vertical depth of cut, and adjusts height of copy table and pantograph.

Range of ratios from 2 to 1 to infinity!

Accessibility on three sides permitting panels up to 30" diameter to be engraved, milled or profiled. Vertical range over 10" allowing operations on complete chassis, cabinets or other bulky objects.

Ruggedness, stability and precise accuracy inherent in construction.

Mounted on the ruggedly constructed heavy duty steel Green Engraver Bench. All functional parts are conveniently within reach of the operator while seated. Accessibility of master type sets stored in lower cabinet trays, tools and accessories contribute to productive capacity.

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For more information circle **154** on inquiry card.

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Write for Bulletin 5

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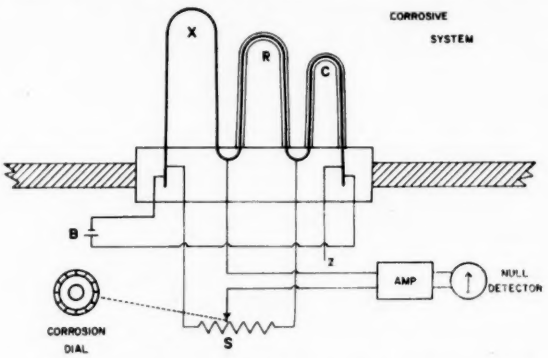
Sales Representatives throughout the United States and Canada.

For more information circle **155** on inquiry card.

Corrosometer

The "Corrosometer" method for measuring corrosion involves installing a special probe in the system under study, and then following the progress of corrosion on the probe electrically by means of a special meter . . . The Corrosometer probe consists essentially of an exposed metal element which is part of an electrical circuit used to make



resistance measurements on the element. The exposed element is made of whatever metal is of interest, and the corrosion measured is that which takes place directly on this element. The Corrosometer is the instrument used to determine the extent of corrosion on the exposed element of a probe by measuring the changes in electrical resistance as the cross-section is reduced. The specially designed meter circuit gives readings directly in terms of microinches of corrosion . . . (*From new 43-page loose leaf folder, including data of 13 tests, Crest Instrument Co.,* 11808 *So. Bloomfield, Santa Fe Springs, Calif.*)

For this literature circle **410** on inquiry card.

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Whatever your relay needs may be, Comar will design and "custom-manufacture" the right relay for you. Electrical characteristics, sizes and mountings are tailor-made to exactly fit your requirements. Precision-engineered, easier to install, more efficient in operation, economical in price. Send for details now!

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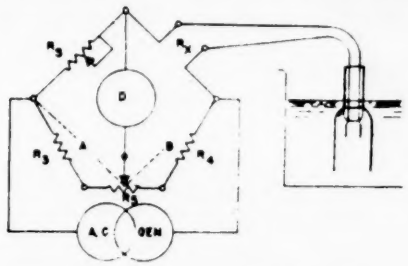
For more information circle **156** on inquiry card.

Solution Conductivity

Electrolytic or solution conductivity is a measure of the ability of a solution to carry an electric current. It is also called specific conductance and is defined as the reciprocal of the resistance in ohms of a 1-cm cube of the



liquid at a specified temperature. The unit of specific conductance is a very large value of electrolytic conductivity, the practical unit is commonly 1 millionth of a mho/cm or 1 micromho/cm . . .

The mechanism of electrolytic conduction differs from that of metals. In the latter, current is carried by ions only. Electrolytic conductivity is non-specific in that all ions present in a solution contribute to the overall conductance . . . The equipment and the methods used for measuring conductivity and pH are entirely different. Conductivity measurement usually involves determination of resistance by an a-c Wheatstone bridge; pH measurements require determination of a d-c potential difference, using a potentiometer circuit or a high-impedance vacuum-tube voltmeter . . . . (*From new 16-page Catalog, 22, Industrial Instruments Inc., 89 Commerce Rd., Cedar Grove, N. J.*)

For this literature circle **411** on inquiry card.

Meter-Relays, VHS Relays, Simplytrol and Versatrol Automatic Controls, Panel Meters and Indicating Pyrometers

40 PAGE ASSEMBLY PRODUCTS CATALOG 4-A

Contents include:

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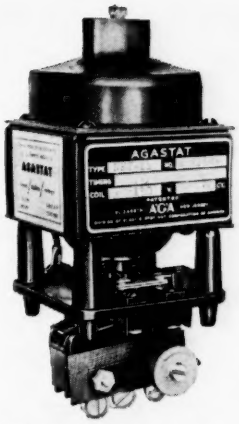

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DEPT. 156

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For more information circle **159** on inquiry card.

INSTRUMENTS and AUTOMATION — New Literature

AUTOMATION

System Load and Frequency Control. New 22-page Bulletin B91-1 describes all-electronic load and frequency control systems for captive plant, small utilities, and multiple station systems.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **413** on inquiry card.

Pneumatic Controllers. New 4-page issue of "Instrumentation News" BN N 101-AC contains description of maker's "Series 500" pneumatic controllers.—Bristol Co., Waterbury 20, Conn.

Circle **414** on inquiry card.

Numerical Control System. New 4-page Brochure A-504-G contains information on maker's "Numill" numerical control system for two dimensional profile milling.—Autonetics Div. of North American Aviation, Inc., 9150 E. Imperial Highway, P. O. Box "AN", Bellflower, Calif.

Circle **415** on inquiry card.

Automatic Wire Termination. New 16-page Bulletin SME-6 pictures and describes maker's "Bandolug" for automatically installing maker's "Insulugs."—Burndy Engineering Co., Inc., Norwalk, Conn.

Circle **416** on inquiry card.

Optimal Controllers. New 16-page booklet presents "Theory and Application" of maker's optimal controllers. —New 8-page brochure and two 4-page booklets describe "Series 700" optimal controller and "Series 800" motor-driven air regulator.—Quarie Controllers, P. O. Box 95, Canton, Mass.

Circle **417** on inquiry card.

Potentiometer-Controller. New 4-page Bulletin F-7968 pictures and describes maker's "Series 150" non-indicating potentiometer-controller.—Wheelco Instrument Div., Barber-Colman Co., Rockford, Ill.

Circle **418** on inquiry card.

Systems Engineering. New 4-page "pop-up" folder shows complete system-simulating laboratory using building blocks for evaluation of system performance.—Servo Corp. of America, New Hyde Park, N. Y.

Circle **419** on inquiry card.

Load Frequency Control. New 11-page Reprint GER-1048 describes "Operating Experience with General Electric's Automatic Dispatching System at Kansas City.—General Electric Co., Schenectady 5, N. Y.

Circle **420** on inquiry card.

Automation. New 8-page booklet contains address by R. T. Sheen describing that "automation cannot be introduced any faster than people are trained to design, build, install, service and supervise automatic equipment."—Milton Roy Co., 1300 Mermaid Lane, Phila. 18, Pa.

Circle **421** on inquiry card.

Dispensing Systems. New 6-page brochure presents information and data on maker's automatic dispensing systems for thermo-setting resins.—Electronic Plastics Co., 675 Barbey St., Brooklyn, N. Y.

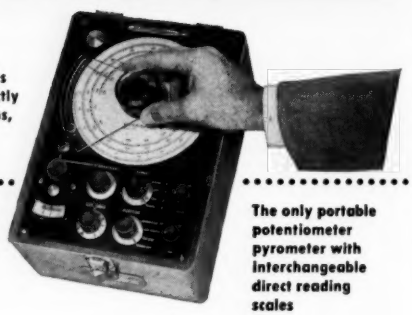
Circle **422** on inquiry card.

Director Systems. New 4-page Bulletin 571 provides data on maker's electro-magnetic director systems for automating products, tools or processes.—Sensory, Inc., New Vernon, N. J.

Circle **423** on inquiry card.

Tape Control System. New 12-page illustrated brochure presents data on

Check and calibrate any type of thermocouple-actuated temperature instrument with one portable Pyrotest



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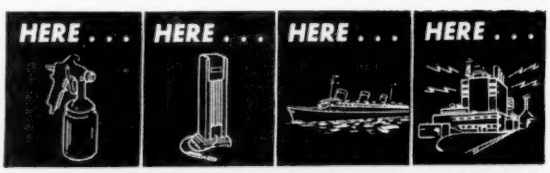

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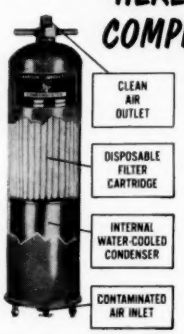

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For more information circle **161** on inquiry card.

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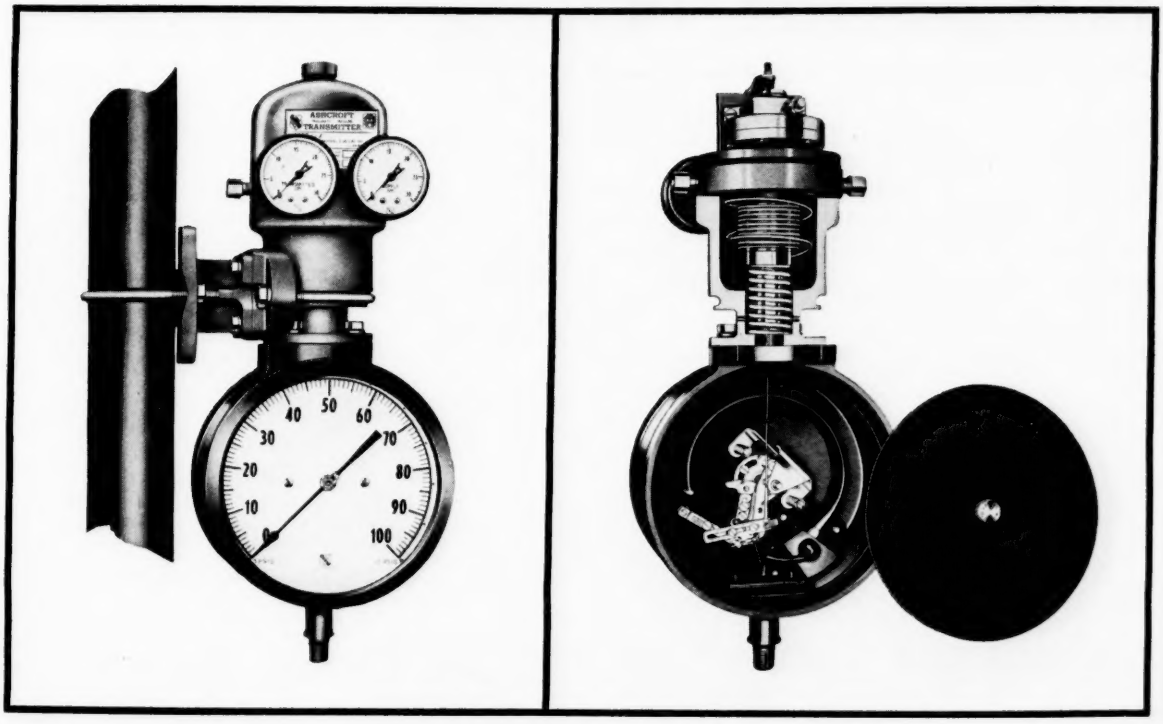

This new Ashcroft Pneumatic Pressure Transmitter is particularly recommended to processing industries and power stations. It combines speed and accuracy with maximum protection and serviceability.

The new design features the 6" indicating Ashcroft Maxisafe Duragauge, long known for dependable performance. It has an integrally-cast solid metal wall between dial and pressure sensitive element so that the transmitter can measure pressures up to 100,000 psi with complete safety for personnel and equipment. If misapplication ruptures the Bourdon tube, the Teflon-coated back cover serves as a safety blowout relief.

Another outstanding design advantage is easy access to both gauge and transmitter sections. Simply remove the safety-relief back cover and both the gauge and transmitter can be calibrated. Yet a sealed housing makes the entire assembly weatherproof.

The transmitter operates on low-pressure air. No need for expensive high-pressure lines and fittings. Supply air pressure as low as 18-20 psi for 3 to 15 psi output provides especially advantageous operation where electrical wiring might be a hazard. Inflammable, poisonous or corrosive liquids or gases are confined close to their source, away from the central control point.

The Series 1250 Ashcroft Pneumatic Pressure Transmitter is available with pressure sensing elements in all standard pressure ranges and Bourdon tube materials. Installation of the transmitter is easy. Small diameter tubing may be used, and the pipe, stem, wall or flush mounts are interchangeable in the field. Get complete operational data and construction details. Write for Bulletin 340.

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For more information circle **162** on inquiry card.

NEW LITERATURE

maker's "Digimatic" tape control system for machine tools.—Electronic Control Systems, Inc., 2136 Westwood Blvd., Los Angeles 25, Calif.

Circle **424** on inquiry card.

Pneumatic Transmitter. New 8-page Bulletin 750 describes maker's "Laminair" pneumatic transmission system. —Simplex Valve & Meter Co., Lancaster, Pa.

Circle **425** on inquiry card.

SERVOS, MOTORS

Servo Gear Box. New 2-page Bulletin LP-3526 presents specifications on maker's "Model 013" high-precision gear box for servo systems.—Link Aviation, Inc., Binghamton, N. Y.

Circle **426** on inquiry card.

Permanent Magnet Motors. Two new 4-page Bulletins F-4344-4 and F-6573-2 describe and illustrate maker's permanent magnet motors.—Electrical Components Div., Barber-Colman Co., Rockford, Ill.

Circle **427** on inquiry card.

VALVES, ACTUATORS

Solenoid Valves. New 2-page Bulletin 8222A describes maker's 2-way solenoid valves for steam, liquids and gases.—Automatic Switch Co., Orange, N. J.

Circle **428** on inquiry card.

Valve Actuator. New 2-page Bulletin D-1 contains information on maker's Series "D" all-electric valve actuator for proportional position electronic control systems.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

Circle **429** on inquiry card.

Bronze Valves. New 4-page Bulletin DH-25 describes manufacturer's line of solder-end and silver-braze-end bronze valves in gate, globe and check designs.—R-P&C Valve Div., American Chain & Cable Co., Inc., Reading, Pa.

Circle **430** on inquiry card.

Actuators. New eight-page bulletin J-100 discusses Electrical Remote Positioning controls for both push button and automatic operation.—The Jordan Co., Inc., 3235 W. Hampton Ave., Milwaukee, Wis.

Circle **431** on inquiry card.

Valve Positioner. New 2-page Bulletin 7501 provides information on maker's electric-to-pneumatic positioner.—Moore Products Co., Phila. 24, Pa.

Circle **432** on inquiry card.

Electrohydraulic Converter. New 8-page Bulletin No. 38.1 contains information on company's high-power electrohydraulic converter.—Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.

Circle **433** on inquiry card.

Control Valve. New 2-page Bulletin M-1 describes maker's Microflex" sleeve valve for remote control of low rates of flow.—Red Jacket Co., Inc., Bell Ave., Carnegie, Pa.

Circle **434** on inquiry card.

TEMPERATURE

Thermistors. New 12-page booklet "Trends and Developments for Electrical Design Engineers" includes information on maker's permanent magnets, thermistors and "Thyrite" varistors.—General Electric, Magnetic Materials Section, Edmore, Mich.

Circle **435** on inquiry card.

Thermometers and Hydrometers. New 28-page booklet 40 contains a complete listing of ASTM, general- and specific-purpose thermometers and hydrometers for industrial and educational measurements, including specifications and prices.—Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.

Circle **436** on inquiry card.

Conversion Table. New 2-page (8½" x 3½") temperature conversion chart is included with illustration of qualities maker's Glass Red Reading Column Thermometer.—Moeller Instrument Co., Richmond Hill 18, New York.

Circle **437** on inquiry card.

Industrial Thermometers. New 16-page brochure pictures and describes maker's industrial (glass) thermome-

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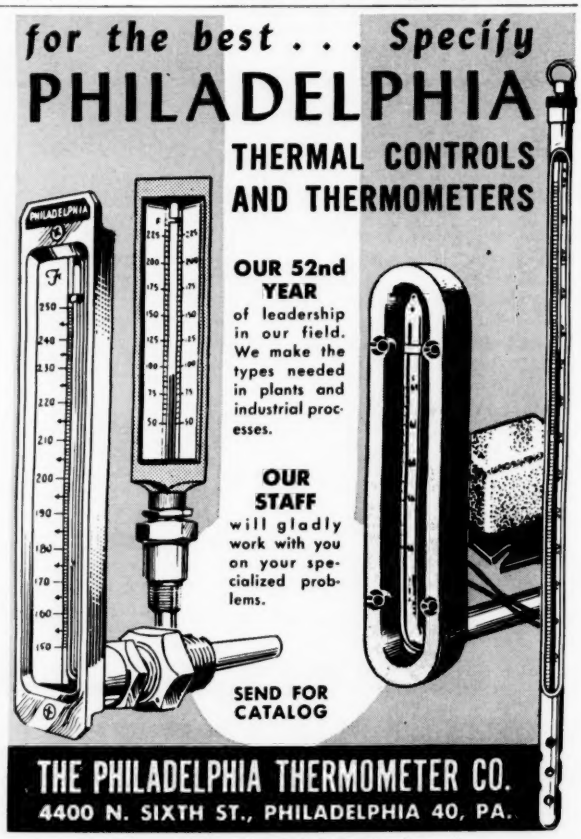
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ters.—Albert A. Weiss & Son, Inc., 261-263 Vanderbilt Ave., Brooklyn 5, N. Y.

Circle **438** on inquiry card.

Temperature Controls. New 2-page Bulletin 106 contains information on maker's "Model L-1S" differential-expansion type temperature controls. —Burling Instrument Co., 16 River Rd., Chatham, N. J.

Circle **439** on inquiry card.

Over-Temperature Thermostat. New 4-page Bulletin RT-809 contains diagrams and cut-away drawings on installation and mechanism of temperature limit control.—Robertshaw-Fulton Controls Co., 110 East Otterman St., Greensburg, Pa.

Circle **440** on inquiry card.

Thermocouple Products. New 12-page brochure presents information on maker's thermocouples, connectors and connector panels.—Thermo-Couple Products Co., 1515 N. 25th St., Melrose Park, Ill.

Circle **441** on inquiry card.

FLOW, PUMPS

Positive Displacement Meters. New 2-page Bulletin #400 discusses meter suitable for hard-to-handle fluids.—Brooks Rotameter Co., Landsdale, Pa.

Circle **442** on inquiry card.

Orifice Fittings. New 20-page 1957 Catalog describes maker's orifice fittings for controlled metering of fluids, gases and vapors.—Commercial Iron Works, 2424 Porter St., Los Angeles 21, Calif.

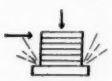
Circle **443** on inquiry card.

Proportioning Pump. New 2-page Sup. Bulletin 1105-3 describes the Model 1105, a low cost, positive displacement metering pump, to accurately proportion various solutions or chemicals.—Proportioneers, Inc., 345 Harris Ave., Providence, R. I.

Circle **444** on inquiry card.

Flow Regulator. New 2-page Data Sheet 1.06 presents sections and dimensional drawings of maker's "Series 1409" adjustable flow regulators. —Waterman Engineering Co., 721 Custer Ave., Evanston, Ill.

Circle **445** on inquiry card.



PRESSURE

Pressure Transmitter. New 2-page Bulletin 501 describes maker's low-differential pressure transmitter.—Burgess-Manning Co., Penn Instruments Div., 4110 Haverford Ave., Phila. 4, Pa.

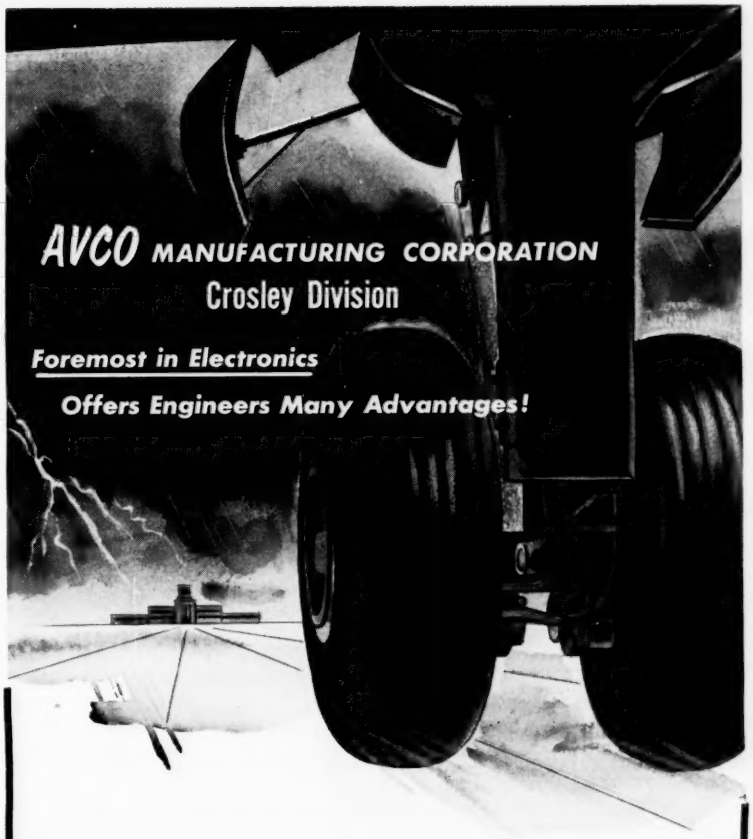
Circle **446** on inquiry card.

Pressure Controls. New 60-page illustrated Catalog 857 presents description, specifications and engineering data for maker's automatic pressure and temperature controls.—Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.

Circle **447** on inquiry card.

Pressure Cells. New 4-page Bulletin 273 presents sizes, ranges, ratings, etc. of maker's pressure sensitive cells. —Clark Electronic Labs., Box 165, Palm Springs, Calif.

Circle **448** on inquiry card.



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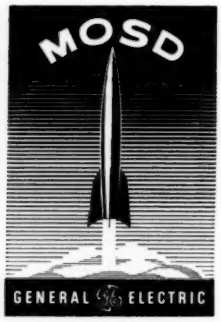

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NEW LITERATURE

Pressure Regulator. New 15-page Bulletin F-15A describes and illustrates regulators for control of air pressure to air-operated equipment.—Watts Regulator Co., Lawrence, Mass.

Circle **449** on inquiry card.

Pressure Switches. New 4-page Brochure SW-1 presents specifications of maker's pressure switches, gear boxes and actuators.—Southwestern Industries, Inc., 5880 Centinela Ave., Los Angeles 45, Calif.

Circle **450** on inquiry card.

Pressure Gages. New 10-page Bulletin M-106 illustrates and describes Kollsman precision pressure gages for testing.—Scientific Instrument Co., 1041 Second Ave., Detroit 26, Mich.

Circle **451** on inquiry card.

COUNTING, SPEED, TIME

Remote Impulse Counting. New 8-page bulletin describes Sodeco Ti Series of Predetermined Electric Impulse Counters and Impulse Transmitters.—Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.

Circle **452** on inquiry card.

Hand-Tachometer. New 4-page Brochure 216 describes maker's "Deumo" precision-hand-tachometer for shaft and surface speeds.—Epic, Inc., 154 Nassau St., New York 38, N. Y.

Circle **453** on inquiry card.

Gate Time Counter. New 4-page "Journal" (Vol. 8 No. 3-4) describes new adjustable gate time counter especially suited for flow measurement.—Hewlett-Packard Co., 275 Page Mill Road, Palo Alto, Calif.

Circle **454** on inquiry card.

Electric Counter. Two new 2-page Bulletins 600 and 601 provide information on maker's Series C-35 "Acratrol" 5-position count selector and controller for predetermined switching with instantaneous, automatic recycling.—Counter and Control Corp., 5225 West Electric Ave., Milwaukee 19, Wis.

Circle **455** on inquiry card.

Electric Counters. New 2-page Bulletin 56-C describes two models of a new electric counter which records up to 200 counts per minute.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

Circle **456** on inquiry card.

Timing Instruments. Loose-leaf folder contains three new 2-page bulletins describing maker's "Model AB Type 2" function programer for control of missile operations and industrial applications.—Hubbard Scientific Labs., Inc., 1292 E. 3rd St., Pomona, Calif.

Circle **457** on inquiry card.

WEIGHING, FORCE

Scale Feeders. Four new 4-page Bulletins Tp-79-M-1; TP-6-M, TP-67-M-3, and TP-68-M, describe maker's

Merchen meter; and pneumatic scale feeders.—Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.
Circle **458** on inquiry card.

Dynamometer. Two new Bulletins 1E & 17E provide information on (1) the Dillon traction Dynamometer for torque, weight, tension, traction, and compression (1E—4 pages), and (2) Dyna-Switch for guarding hoist overload (17E—2 pages).—W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.
Circle **459** on inquiry card.

Automatic Batching System. New 4-page Bulletin H-561 describes and illustrates maker's electronic punch-card batching system which provides automatic recording, inventory, and billing.—Heltzel Steel Form & Iron Co., Warren, Ohio.
Circle **460** on inquiry card.

OPTICAL

Cameras, Projectors, Accessories. New 104-page Catalog 956-M pictures and describes maker's cameras, developing equipment, exposure meters, magnifiers, tape recorders, slide viewers, etc.—Burke & James, Inc., 321 So. Wabash Ave., Chicago 4, Ill.
Circle **461** on inquiry card.

Periscopes. New 4-page bulletin contains information on maker's industrial periscopes for remote observation of inaccessible places or hazardous processes.—Lenox Instrument Co., 2010 Chancellor St., Phila. 3, Pa.
Circle **462** on inquiry card.

Borescopes. New 2-page bulletin pictures and describes maker's "Model TG-1" borescopes used for examining diesel injection nozzles and other small tubes and cavities.—Kollmorgen Optical Corp., 347 King St., Northampton, Mass.
Circle **463** on inquiry card.

Glass Filters. New 16-page Bulletin "Color and Transmission Properties of Sharp Cut-Off Red Glass Filters at Elevated Temperatures" contains data and graphs.—Kopp Glass Inc., Swissvale, Pa.
Circle **464** on inquiry card.

STEAM, AIR

Desuperheater. New 4-page Brochure M 55-1 describes design, installation, and typical application of high-capacity spray-type steam desuperheater.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.
Circle **465** on inquiry card.

Instrument Air Dryer. New 4-page Catalog describes Model CMK-1 instrument air dryer especially for isolated pneumatic equipment on dead end and low flow service.—King Engineering Corp., Ann Arbor, Mich.
Circle **466** on inquiry card.

Steam Jet Heater. New 2-page issue of Engineering News Letter, Vol. 1, No. 9, contains information on maker's steam jet heater.—Schutte and Koerting Co., 2255 State Road, Cornewells Heights, Bucks County, Pa.
Circle **467** on inquiry card.

Air Sampler. New 4-page Bulletin 1H-3 provides information on maker's

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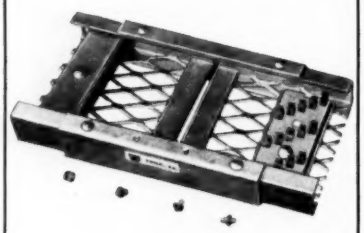

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NEW LITERATURE

hi-volume air sampler.—The Staplex Co., Air Sampler Div., 777 Fifth Ave., Brooklyn 32, N. Y.

Circle **468** on inquiry card.

ANALYTICAL LABORATORY

Gas Analyzer. New 4-page Bulletin 0716-1 describes and illustrates maker's "Thermatron" for process control and industrial gas analysis application.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

Circle **469** on inquiry card.

Infrared Analyzers. New 8-page Bulletin 0705-2 describes maker's sensitive high-speed analyzer for complex streams.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

Circle **470** on inquiry card.

Chromatography Equipment. New 6-page Bulletin 80 lists maker's paper chromatography and electrophoresis equipment.—Central Scientific Co. of Calif., 6446 Telegraph Rd., Los Angeles 22, Calif.

Circle **471** on inquiry card.

Sulfur Analysis. New 10-page bulletin describes and illustrates Leco combustion sulfur analysis apparatus.—Laboratory Equipment Corp., St. Joseph, Mich.

Circle **472** on inquiry card.

Analytical Instruments. Three new 2-page bulletins describe, (1) Oxygen Analyzer Type 38-301 (Bulletin 1841), (2) Ultraviolet Analyzer Type 38-401 (Bulletin 1842), (3) Vaporizer Regulator. 38-001 (Bulletin 1832).—Consolidated Electrodynamics, 300 North Sierra Madre Villa, Pasadena, Calif.

Circle **473** on inquiry card.

Differential Refractometers. New 8-page Bulletin R1000 announces 8 new refractometers for use in laboratory, pilot plant and process control applications.—Phoenix Precision Instrument Co., 3803-05 N. 5th St., Phila. 40, Pa.

Circle **474** on inquiry card.

Blood Analyzer. New 4-page bulletin describes maker's Autoanalyzer for determining urea, sugar and calcium by automatic colorimetric analysis.—Technicon Instruments Corp., Chauncey, N. Y.

Circle **475** on inquiry card.

Platinum Electrodes. New 8-page brochure presents data on maker's platinum electrodes.—4-page bulletin illustrates platinum laboratory apparatus.—J. Bishop & Co., Malvern, Pa.

Circle **476** on inquiry card.

Laboratory Instrumentation. Four new bulletins describe laboratory instrumentation distributed by company. 8-page Bulletin D-5426 contains information on Beckman Gas Chromatograph, International Model CM Centrifuge, Temco Hotplates, etc.; 8-page Bulletin 376-C presents Thelco line of ovens and incubators; and two

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For more information circle **170** on inquiry card.

2-page leaflets describe and illustrate Leco Sulfur Titrators and Purifying Train.—Harshaw Scientific, Div. of the Harshaw Chemical Co., 1945 E. 97 St., Cleveland 6, Ohio.

Circle **477** on inquiry card.

Laboratory Apparatus. New 4-page Bulletin 5225 describes "Blue M's" "Vapor-Temp" relative humidity chamber.—New 4-page bulletin describes "Quikpure-Unibed" water demineralizer.—Two new 2-page bulletins discuss "Sartorius Selecta" speed balances and "Sauter" precision balance.—Boder Scientific Co., 810-814 Penn Ave., Pittsburgh 22, Pa.

Circle **478** on inquiry card.

Needle Valves. New 4-page illustrated Brochure M 1017 describes maker's glass and teflon needle valves with Pyrex brand glassware.—Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.

Circle **479** on inquiry card.

Laboratory Apparatus. New 4-page Catalog 602 pictures and describes maker's constant temperature equipment, syringe-pipettes, oscillating water bath, etc. 4-page Catalog 254 illustrates and specifies maker's paper electrophoresis apparatus, power supplies, etc.—Research Specialties Co., 2005 Hopkins St., Berkeley 7, Calif.

Circle **480** on inquiry card.

Laboratory Glass. New 8-page Catalog 8D gives data tabulations and price information on Glenlab laboratory glass products.—Glass Engineering Laboratories, 550 O'Neill Ave., Belmont, Calif.

Circle **481** on inquiry card.

Carbon Determinator. New 6-page Bulletin 102 provides information for extremely accurate analysis of very low carbon contents of steel, iron, ferro-alloys and many other materials.—Laboratory Equipment Corp., St. Joseph, Mich.

Circle **482** on inquiry card.

NUCLEONICS

Low Level Period Amplifier. New 4-page Specification S901-5 describes and illustrates the Brown Low Level Period Amplifier used for nuclear reactor startup.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **483** on inquiry card.

Radiation Spectrometer. New 4-page bulletin describes the Model SR-300, for geophysical measurements.—Mount Sopris Instrument Corp., 1320 Pearl Street, Boulder, Colo.

Circle **484** on inquiry card.

Radiation Shielding. New 12-page Bulletin PE-51 gives information on maker's radiation shielding windows; includes charts, graphs and sketches to explain shielding, transmittance and radiation darkening characteristics of 2.7, 3.3 and 6.2 density shielding glasses.—Plant Equipment Sales Dept., Corning Glass Works, Corning, N. Y.

Circle **485** on inquiry card.

ULTRASONICS

Ultrasonic Apparatus. New 2-page bulletin describes ultrasonic generators and transducers.—Acoustic Associates, 2917 W. Beverly Blvd., Los Angeles 57, Calif.

Circle **486** on inquiry card.

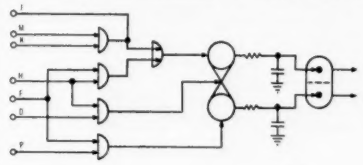
EECO Data Sheet

- Gray-to-binary code conversion with new EECO Computer-Series plug-in (Y-103).
- Small Engineering Company Organization—a philosophy and method for tailoring operating procedures.

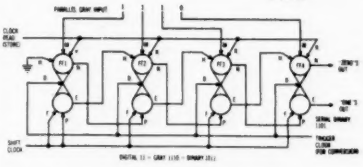
Y-103

Gray-to-binary Code Converter

Included among the many functional circuits available in EECO's new Computer-Series plug-ins is a Flip-Flop – Shift Register Element (Y-103) that is



Y-103



adaptable for use as a composite Gray-to-binary code converter and shift register. For this use, the Gray number is read into the shift register in parallel form (for example, from a code wheel or flip-flop register), converted internally to a binary number, and then shifted out in serial form.

In the schematic illustration, the input Gray number is 1110, corresponding to decimal 11 and binary 1011. The Gray-to-binary conversion is based on the rules that:

1. The most significant digit is identical in each code system.
2. Each succeeding Gray digit is complemented if the preceding *binary* digit is a 1, or repeated if the *binary* digit is a 0.

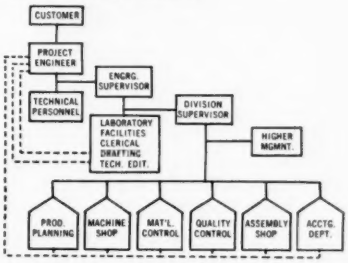
Trigger clock (conversion) pulses cause the Gray-to-binary conversion and must be one less in number than the number of digits in the Gray code. After conversion, the binary number is shifted out serially by shift clock pulses.

More detailed information on this and other applications of EECO Standard-Series and new Computer-Series plug-ins is available in Catalog No. 856-A. Write for your copy.

Tailor-Making a Company Organization

Each of the two classical types of company organization – "Project" and "Departmental" – has weak as well as strong points. By combining the strong and eliminating the weak points of the two (insofar as practicable within the limits imposed by the type of company activities and objectives involved) it is possible to evolve a third system superior to either of the original two.

This complete analysis and integration process is described in detail in the reprint of a talk delivered by T. W. Jarmie, president of Engineered Electronics Co. and a director of Electronic Engineering Co. of California, before the Professional Group on Engineering Management of the IRE. The final operation chart developed by this process (illustrated below) reflects the operating procedure that has proven so successful at EECO.



Although this talk was first delivered in 1955, so much recent interest has been shown in the subject that reprints of the paper have again been made available. Ask for Reprint J-2.

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NEW LITERATURE

tor with wide frequency range and adjustable power output; 2-page bulletin describes ultrasonic viscosimeter; 2-page bulletin describes ultrasonic electron multiplier photometer. —Ultrasonic Engineering Co., P. O. Box 46, Maywood, Ill.

Circle **486** on inquiry card.

COMPUTERS, DATA HANDLING

Digital Comparator. New 4-page Bulletin 418 provides information on solutions to digital servo problems.—Norden-Ketay Corp., Norden Laboratories Div., 13210 Crenshaw Blvd., Gardena, Calif.

Circle **487** on inquiry card.

Data Handling System. New 2-page technical bulletin describes the 5780 data handling system featuring high-speed storage on magnetic tape, playback into electric typewriter on serial IBM summary punch, continuous time readout; also, basic units of high-speed gated counters, tape converters, and magnetic shift registers.—Berkeley Div., Dept. 4061, 2200 Wright Ave., Richmond 3, Calif.

Circle **488** on inquiry card.

Digital Equipment. New 16-page Bulletin "Four Dimensions in Digital Design" describes the application of maker's digital equipment to control systems.—Burroughs Corp., 1209 Vine St., Phila. 7, Pa.

Circle **489** on inquiry card.

Analog Computers. New 8-page booklet "High-Speed Analog Computers, Key to Rapid System Development" presents in question and answer form definitions of various types computers and summarizes applications of each.—GPS Instrument Co., Inc., 811 Boylston St., Boston 16, Mass.

Circle **490** on inquiry card.

RECORDERS

Gloss Recorder. New Gardner Newsletter No. 19 describes maker's Dust Compensated Automatic 75° Gloss Recorder for continuous gloss measurement of materials such as paper, linoleum, fabrics, plastics, metals, etc.—Gardner Laboratory, Inc., Bethesda 14, Md.

Circle **491** on inquiry card.

Tape Recorders. New 16-page Bulletin MC-156-10M presents data on maker's "Magnecord" tape recorders. Includes 6-page price list.—Magnecord, Inc., 1101 S. Kilbourn Ave., Chicago 24, Ill.

Circle **492** on inquiry card.

Surface Recorder. New 4-page bulletin LT-24 provides information on the new "Proficorder" for measuring and recording surface profiles.—Micrometrical Mfg. Co., 345 South Main St., Ann Arbor, Mich.

Circle **493** on inquiry card.

Graphic Recording. Three new 4-page bulletins in loose leaf binder describe maker's facsimile transmitters and recorders.—Alden Electronic and Impulse Recording Equipment Co., Westboro, Mass.

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MEMO TO MANUFACTURERS

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Recording Oscillograph. New 4-page Bulletin describes recording electrograph "Model 420" using light beam galvometers.—Century Electronics & Instruments, Inc., 1333 No. Utica, Tulsa, Okla.

Circle **495** on inquiry card.

MONITORS

Radiation Monitoring System. New 4-page Bulletin 3045 gives information on uses of maker's remote area radiation monitoring system, and specification data on units.—The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

Circle **496** on inquiry card.

Basic Sediment & Water Monitor. New 4-page booklet provides information for measuring and controlling the B. S. & W. content of crude oil at automatic custody transfer installations with maker's monitor.—Instruments, Inc., 122 North Madison, Tulsa, Okla.

Circle **497** on inquiry card.

GAGING, TESTING

Thickness Gage. New 2-page Data Sheet No. 10.9-3 describes Curtiss-Wright Radiation gage used with Brown Strip Chart Recorder for continuous non-contact measurement of weight per unit area of sheet materials.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **498** on inquiry card.

Testing Instrument. New 2-page issue of "Electrical Component News" (Vol. 1, No. 4) features article on use of Hypot testers with maker's micropositioner in leakage detection circuits.—Barber-Colman Co., Rockford, Ill.

Circle **499** on inquiry card.

Hardness Testing. New 2-page Bulletin R-10 pictures and describes maker's shore durometers for testing hardness of rubber, etc.—The Shore Instrument & Mfg. Co., Inc., 90-35 Van Wyck Expressway, Jamaica 35, N. Y.

Circle **500** on inquiry card.

Test Set. New 4-page brochure describes maker's "Model 815" recording life test set for transistors and tubes.—Systems Development, Inc., 307 Water St., Binghamton, N. Y.

Circle **501** on inquiry card.

Precision Spherometer. New 2-page Bulletin E 1309a describes imported high-accuracy instruments for measuring radius of curvature or thickness.—Epic Inc., 154 Nassau St., New York 38, N. Y.

Circle **502** on inquiry card.

Dial Snap Gages. New 8-page bulletin pictures and describes maker's dial snap gages with "Paralloc" locking mechanism.—Standard Gage Co., Inc., Poughkeepsie, N. Y.

Circle **503** on inquiry card.

Vibration Testing. New 2-page Bulletin A-14-28-5659 describes the special features of portable Model 14-28.—The Ahrendt Instrument Co., College Park, Md.

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NEW LITERATURE

Lead Comparator. New 2-page bulletin illustrates and specifies Bench-Model SK-1003 Lead Comparator.—Jerpbak Bayless Co., Solon Road, Solon, Ohio.

Circle **505** on inquiry card.

FITTINGS, TUBING

Tube Fittings. New 28-page Catalog 4320 gives complete data on maker's "Ferulok" flareless type tube fittings.—Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle **506** on inquiry card.

Hose Fittings. New 4-page Catalog 4433 describes maker's "Hoze-lok 33" hydraulic hose fittings for high-pressure applications.—Parker Appliance Co., Tube & Hose Fittings Div., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle **507** on inquiry card.

Tube Cutter. New 2-page illustrated Bulletin 3058 describes maker's tube cutter and flaring tool for nylon tubing.—Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.

Circle **508** on inquiry card.

Teflon-lined Pipe. New 2-page Bulletin T-100 details the application of Teflon as a liner for schedule 80 steel pipe; also, solving corrosion problems in chemical, petroleum, pharmaceutical and food processing, plus other allied industries.—Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Dela.

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Teflon Tubing. New 2-page Bulletin T-200 provides information on thin-walled Teflon tubing.—Haveg Industries, Inc., 950 Greenbank Road, Wilmington 8, Dela.

Circle **510** on inquiry card.

Tubing & Fittings. New 6-page Bulletin No. V-157 presents Vacu-Flo steel tubing and fittings for vacuum systems and conveying lines—standard slip joint, welded steel, black or zinc coated.—H-P Products, Inc., Louisville, Ohio.

Circle **511** on inquiry card.

Tube Fittings. New 48-page Catalog Form 6071 incorporates complete engineering data on makers' 7000 series and 800 series Ermeto hydraulic flareless tube fittings, and "Flare-Twin" S.A.E. 37° Flare (J.I.C.) hydraulic tube fittings.—The Weatherhead Co., Fort Wayne Div., Fort Wayne, Indiana.

Circle **512** on inquiry card.

RADIO, ITV

Sun Battery Radio. New 6-page October-November 1956 issue of Rectifier News RN-1156 contains description of a radio with a built in speaker operated by the action of light on a photoelectric battery.—International Rectifier Corp., 1521 East Grand Ave., El Segundo, Calif.

Circle **513** on inquiry card.

Industrial Television. New 8-page Bulletin PC 6582JW provides information covering Philco's newly designed line of ITV equipment.—Philco Corp., Government and Industrial Div., 4700 Wissahickon Ave., Phila. 44, Pa.

Circle **514** on inquiry card.

Radio, TV, Electronics. New 172-page Catalog No. 571 lists a complete buying guide for everything in Radio, TV, Electronics.—Burstein-Applebee Co., 1012-14 McGee St., Kansas City 6, Mo.

Circle **515** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Universal Potentiometer. New 6-page Data Sheet E-51(6) describes the Type K-3 Universal (Guarded) Potentiometer with complete specifications and typical applications.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **516** on inquiry card.

DC Magnet Brake. New 8-page Bulletin GEA-6214 discusses single-point adjustment with its features, simplified installation and maintenance procedures, contains 4-color cutaway drawing, applications, diagrams and table that show how brake meets AISE standards.—General Electric Co., Schenectady 5, N. Y.

Circle **517** on inquiry card.

Telescriber. New 4-page Bulletin 56A describes maker's electronic longhand telescribing system.—TelAutograph Corp., 8700 Bellanca, Los Angeles 45, Calif.

Circle **518** on inquiry card.

Electromagnet. New 2-page bulletin discusses a new horizontally-rotating version of the Varian twelve-inch Electromagnet.—Varian Associates, Palo Alto, Calif.

Circle **519** on inquiry card.

Electronic Volt-Ohmmeter. New 2-page Bulletin 415 provides information and illustrations on small sized portable Electrometer Volt-Ohmeter.—The Hickok Electrical Instrument Co., 10528 Dupont Ave., Cleveland 8, Ohio.

Circle **520** on inquiry card.

Batteries. Eleven new 2-page specification sheets (Handbook Section 4A) on maker's batteries for transistor and electronic applications are available showing characteristics.—Ray-O-Vac Co., 212 E. Washington Ave., Madison 10, Wisc.

Circle **521** on inquiry card.

Ground Detector. New 12-page booklet "The Brunt Faultfinder" describes company's three models of instrument for quickly locating grounds on energized power circuits by an audible signal.—Parr Mfg. Corp., 48 Hale St., Cranford, N. J.

Circle **522** on inquiry card.

Transformers and Reactors. New eight-page Catalog 105 describes the complete line of Input, Output, Interstage and AVC Output transformers and reactors.—Southwestern Industrial Electronics Co., Houston, Tex.

Circle **523** on inquiry card.

Magnetic Amplifiers. New 2-page bulletin presents specifications of maker's "Blue Line" premium magnetic amplifiers.—Feedback Controls, Inc., 899 Main St., Waltham 54, Mass.

Circle **524** on inquiry card.

Electronic Instruments. New 16-page issue of "This Month" (Jan./Feb. '57) presents list of amplifiers,

magnetic brakes, capacitors, precision dials, motors, magnets, relays, switches, timers, transformers, etc., distributed by company.—Herbach & Rademan, Inc., 1204 Arch St., Phila. 7, Pa.
Circle **525** on inquiry card.

Transistor Voltmeter. New 2-page Bulletin V 801 lists specifications, and describes circuit and operation of maker's ultra-sensitive d-c voltmeter. —Millivac Instrument Corp., P. O. Box 997, Schenectady, N. Y.
Circle **526** on inquiry card.

Voltmeters. New 2-page Catalog 1108 illustrates maker's a-c rectifier type panel voltmeter.—Phaostron Instrument & Electronic Co., 151 Pasadena Ave., South Pasadena, Calif.
Circle **527** on inquiry card.

Color Display Generator. New 2-page Bulletin 660 lists special design features and specifications of new white dot-bar color display generator. —The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.
Circle **528** on inquiry card.

Traveling Wave Tube Amplifier. New 4-page short-form catalog describes maker's traveling wave tube amplifiers, high-voltage power supplies, vacuum gauge, and power controls.—Alfred Electronics, 897 Commercial St., Palo Alto, Calif.
Circle **529** on inquiry card.

Calorimeter. New 8-page issue of PRD Reports (Vol. 5 No. 1) describes and illustrates the calorimeter for centimeter- and millimeter-wave power measurements.—Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.
Circle **530** on inquiry card.

TRANSISTORS, TUBES

Silicon Transistors. New 4-page Bulletin DL-S 635 describes maker's "Types 2N117 and 2N118" N-P-N grown junction silicon transistors.—Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Texas.
Circle **531** on inquiry card.

Multiplier Phototube. New 4-page brochure discusses maker's "Type K1382" antimony multiplier phototube.—Allen B. DuMont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.
Circle **532** on inquiry card.

Tubes and Components. New 64-page booklet "Computer Tubes" presents specially designed tubes and components for electronic computers —computer tubes, transistors, diodes, and counter tubes.—Sylvania Electric Products Inc., Dept. K40P, 1740 Broadway, New York 19, N. Y.
Circle **533** on inquiry card.

Phototransistor. New 2-page Bulletin G-1 illustrates and specifies maker's alloyed junction phototransistors. —General Transistor Corp., 130-11 90th Ave., Richmond Hill 18, N. Y.
Circle **534** on inquiry card.

SWITCHES, RELAYS

Commutating Switch. New 2-page Data Sheet S56-08 presents specifications of maker's commutating switch. —Norwood Controls, 934 Washington St., Norwood, Mass.
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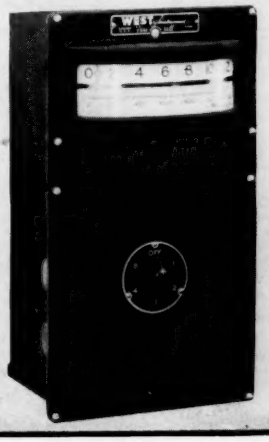

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Mercury Plunger Relays. New 4-page bulletin provides information on the complete Adlake line of mercury plunger-type relays.—The Adams & Westlake Co., Elkhart, Ind.

Circle **536** on inquiry card.

Power Relays. New Bulletin W75 presents data on maker's "Diamond H" Series W power relays for automation equipment, etc.—Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn.

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RESISTORS, POTENTIOMETERS

Rheostats. New 8-page Bulletin GEA-6474 presents plate-type rheostats with greater watt capacity for given plate size, rugged metal-clad construction with a variety of mounting forms available.—General Electric Company, Schenectady 5, N. Y.

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Carbon Resistors. New 4-page Bulletin B-6b features Boron carbon "precistors" with data on construction, characteristics, applications, types, identification, etc.—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

Circle **539** on inquiry card.

A. C. Hypot. New 2-page data sheet describes maker's "Model 4300" portable, bench type 30,000-volt a-c Hypot for testing plastics or other insulation material.—Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.

Circle **540** on inquiry card.

POWER SUPPLIES

Power Supply. New 2-page data sheet describes Series Z-95000 power supplies used for plug-in circuits.—EECO Production Co., 506 E. First St., Santa Ana, Calif.

Circle **541** on inquiry card.

Power Supplies. Six new two-page Bulletins (No. 93, 96, 100, 103, 178, 800) provide information on maker's new power supplies and motor speed control.—Opad Electric Co., 69 Murray St., New York 7, N. Y.

Circle **542** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

Input Transformers. New 2-page Bulletin S 900-1 describes Brown Input Transformers now available for many low-level a-c and d-c servo, measuring and coupling circuits.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **543** on inquiry card.

Electrical Contacts. New 4-page Catalog C-522 describes materials, properties, forms and uses of maker's line of electrical contacts.—Gibson Electric Co., 8375 Frankstown Ave., Pittsburgh 21, Pa.

Circle **544** on inquiry card.

Automation Components. New 10-page loose leaf catalog provides information, data and prices on precision components for automation stocked

by company.—Servo Systems Co., 55 Meeker Ave., Newark, N. J.

Circle **545** on inquiry card.

Instrument Choppers. Three new 2-page bulletins describe and specify maker's "1200" Series Chopper models for low- and high-frequency operation designed for long life with low residual noise and capable of withstanding extreme environmental conditions.—James Vibrapowr Co., 4050 North Rockwell St., Chicago 18, Ill.

Circle **546** on inquiry card.

Storage Batteries. New 8-page Bulletin No. 501 describes high output sintered plate nickel cadmium storage batteries for electronic, aircraft, and communications equipment with details of development, construction, and operation.—Nickel Cadmium Battery Corp., 66 Pleasant St., Easthampton, Mass.

Circle **547** on inquiry card.

Cooling Panel. New 2-page Catalog Sheet 50107-1 gives makers' new RF cooling panel—a flushing fan and filter combination assembly—including features of full 2" thick dustfilter, "Filter Pilot" safety gage, good for 125°F ambient, entirely per Retma standards.—Rotron Mfg. Co., Inc., Schoonmaker Lane, Woodstock, N. Y.

Circle **548** on inquiry card.

Oil-Tight Control Units. New 3-page Booklet "C-H Master Design" provides information on maker's oil-tight line of push buttons, indicating lights, selector switches, etc.—Cutler-Hammer Inc., 315 N. 12th St., Milwaukee 1, Wisconsin.

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Transformer Laminations. New 2-page catalog contains information and specifications on maker's 3/16" E & I transformer laminations including 3 basic formulae for core stock with square cross section at 60 cycles.—Temple Mfg. Co., Bryn Mawr at Damen, Chicago 26, Ill.

Circle **550** on inquiry card.

Circuit Components. New 4-page bulletin presents specifications of maker's "Maximag" magnetic amplifier circuit components.—Adler Electronics, Inc., One LeFevre Lane, New Rochelle, N. Y.

Circle **551** on inquiry card.

Line Tunable Load. New 2-page data sheet provides information on maker's ⅞" line tunable load for use from 1000 Mc to 4000 Mc and other components.—Radar Design Corp., 210 Fifth Ave., New York 16, N. Y.

Circle **552** on inquiry card.

Directional Couplers. New 2-page data sheet covers maker's complete line of 10, 20, and 30 db coaxial directional couplers.—Narda Corp., 160 Herricks Rd., Mineola, L. I., N. Y.

Circle **553** on inquiry card.

Precision Capacitor. New 2-page bulletin pictures and describes maker's "V-Cap" precision-adjustable capacitor.—Balco Research Labs., Inc., 49-53 Edison Place, Newark 2, N. J.

Circle **554** on inquiry card.

Carbon Film Resistors. New 2-page Bulletin 307 presents specifications of maker's ceramic encased carbon film resistors and coated carbon film resistors.—Continental Carbon Div., Wirt Co., 5221 Greene St., Phila. 44, Pa.

Circle **555** on inquiry card.

Coils. New 8-page Bulletin S-20 describes construction of Stonite vacuum impregnated coils.—Stonite Coil Corp., Yardville 20, N. J.

Circle **556** on inquiry card.

Electric Eyes. New 14-page Bulletin 562 illustrates maker's line of miniaturized electric eyes.—ESS Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.

Circle **557** on inquiry card.

Germanium Rectifiers. New 4-page Bulletin GL-1 describes maker's "Golden Line" germanium rectifiers.—Rapid Electric Co., 2881 Middletown Rd., New York 61, N. Y.

Circle **558** on inquiry card.

CONNECTORS, WIRE

Strip Terminals. New 4-page bulletin covers maker's line of "Fingrip" quick-disconnect strip terminals.—Burndy, Omaton Div., Norwalk, Conn.

Circle **559** on inquiry card.

Wire Terminals. New 8-page Bulletin Mag 55 describes maker's "Magnecrimp" method for terminating square, rectangular and round magnet wire.—Burndy Engineering Co., Inc., Norwalk, Conn.

Circle **560** on inquiry card.

Terminals, Links. New 12-page illustrated Bulletin YAE54 describes maker's "Insulugs" nylon-insulated terminals and "Insulinks" nylon-insulated links.—Burndy, Norwalk, Conn.

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NEW LITERATURE

Connectors. New 11-page Bulletin YIC-6 provides information on color-coded compression connectors for shielded wire, coaxial cable, heating elements, solid-to-stranded connections.—Burndy, Norwalk, Connect.

Circle 562 on inquiry card.

Water-Sealed Splice. New 4-page bulletin describes maker's "Sealink" water-sealed splice for cable junctions.—Burndy Corp., Norwalk, Conn.

Circle 563 on inquiry card.

Wire Coding. New 2-page bulletin illustrates and describes method of coding wire with plastic tubular markers.—E.C.P. Corp., 6808 Wade Park Ave., Cleveland 3, Ohio.

Circle 564 on inquiry card.

MECHANICAL COMPONENTS

Miniature Bearings. New 16-page catalog lists miniature ball and roller bearings of the RMB line (made in Switzerland), giving drawings, full descriptions, dimension tables, and mounting information.—Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.

Circle 565 on inquiry card.

Electromechanical Assembly Kits. New Wall Chart SBI-1 gives tables of common gear ratios and moments of inertia for maker's gears.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.

Circle 566 on inquiry card.

Microsize Socket Screws. New 4-page Folder 2055 shows Microsized Unbrako Socket Screws designed for electronic equipment, industrial and scientific instruments, and precisely-built compact products.—Standard Pressed Steel Co., Box 952, Jenkintown, Pa.

Circle 567 on inquiry card.

Stainless Fasteners. New 8-page brochure presents stock list of maker's stainless steel fasteners.—All-metal Screw Products Co., Inc., 821 Stewart Ave., Garden City, L. I., N. Y.

Circle 568 on inquiry card.

Three Dimensional Cams. New 4-page Bulletin 4558 provides information on maker's 3-dimensional cams.—Parker Stamp Works, Inc., Cam Div., Franklin Ave., Hartford, Conn.

Circle 569 on inquiry card.

Ball Bearings. New 32-page illustrated Catalog AFB-1 presents complete information on maker's anti-friction bearings.—Industrial Tectonics, Inc., Western Div., 5010 E. Washington Blvd., Los Angeles 22, Calif.

Circle 570 on inquiry card.

MATERIALS

Ceramic Permanent Magnets. New 2-page Bulletin 16 describes Indox V, the new high-energy ceramic permanent magnet. Contains also data and charts on the material.—The Indiana Steel Products Co., Valparaiso, Indiana.

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Stainless Castings. New 28-page Catalog SS22 provides information and data on stainless steel castings, including physical properties and chemical compositions.—Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa.

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NEW LITERATURE

Synthetic Rubber. New 16-page Booklet A-2972 contains information on neoprene and "Hypalon" synthetic rubbers.—E. I. DuPont De Nemours & Co. Inc., Wilmington 98, Del.

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Encapsulating Material. New 2-page Bulletin TB18 contains pertinent information on "Sonite" filled epoxy resins and methods for proper encapsulation work.—Smooth-On Manufacturing Co., 572 Communipaw Ave., Jersey City 4, N. J.

Circle 574 on inquiry card.

Silicone Compounds. New 11-page booklet contains latest information on maker's heat resistant silicones, low shrinkage silicones, precision molded parts, and DC-301 Silicone Molding Compound.—Acushnet Process Co., New Bedford, Mass.

Circle 575 on inquiry card.

Glass. New 68-page illustrated Catalog 56-12659 describes manufacturing methods, applications and history of glass industry.—Corning Glass Works, Corning, N. Y.

Circle 576 on inquiry card.

VIBRATION

Vibration Seismograph. New 4-page bulletin pictures and describes maker's portable blast and vibration seismograph.—W. F. Sprengnether Instrument Co., Inc., 4567 Swan Ave., St. Louis 10, Mo.

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Vibration Test Equipment. Six new 2-page bulletins picture and describe maker's Model 98 servo control (Bull. 98-56); Model 54 signal monitor (Bull. 54-56); Model 135 crossover servo control (Bull. 135-56); Model 142 frequency sweep cycler (Bull. 142-56); Models 174 and 177 "Wide Band" shakers (Bulls. 174-56 & 177-56).—Calidyne Co., Winchester, Mass.

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FABRICATION

Flotrusion. New 2-page Bulletin describes typical parts which can be produced by the new "Flotrusion" process for cold flowing various metals into tubular forms.—Claude C. Slate Co., 1733 Flower St., Glendale 1, Calif.

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Boring Bar. New 2-page bulletin pictures and describes maker's vibration-proof and chatterless boring bars. Includes stock sizes and prices.—Modern Mfg. Co., Inc., Edgemont & Clementine St., Phila. 34, Pa.

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MISCELLANEOUS

Reproduction Equipment. New 4-page brochure illustrates and explains how "Rectigraph" equipment photocopies 4,000 to 8,000 items a week—typed, written, printed, drawn or photographed.—The Haloid Co., Rochester 3, N. Y.

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Humidity Controllers. New 4-page bulletin illustrates and gives pertinent data on "Serdex" indicating, recording and/or controlling humidity instruments.—Gardner Laboratory Inc., P. O. Box 5728, Bethesda 14, Md.

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Chlorine Evaporator. New 4-page Catalog 70-21 presents specifications of maker's chlorine evaporator.—Fischer & Porter Co., 380 Jacksonville Rd., Hatboro, Pa.

Circle 583 on inquiry card.

Water Monitor. New 4-page brochure discusses maker's monitor for measuring and controlling the basic sediment and water content of crude oil.—Instruments, Inc., 122 North Madison, Tulsa, Okla.

Circle 584 on inquiry card.

Self-sticking Labels. New 2-page pamphlet 160-1 describes and specifies maker's self-sticking labels which find use for wiring diagrams, instruction sheets, manufacturer's nameplates, etc.—W. H. Brady Co., 727 West Glendale Ave., Milwaukee 9, Wis.

Circle 585 on inquiry card.

Blood Counting. New 4-page catalog describes maker's "Mark IV" Arithmometer for automatic blood counts of red and white cells.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle 586 on inquiry card.

Lighting System. New 12-page Bulletin 243 discusses maker's "Type 32EL—Series 300" standard emergency lighting system.—Standard Electric Time Co., Springfield 2, Mass.

Circle 587 on inquiry card.

Templates. New 4-page leaflet describes maker's set of four templates of ellipses with 20°, 25°, 45°, and 60° projection.—RapiDesign Inc., Box 592, Glendale, Calif.

Circle 588 on inquiry card.

Foil Wire Markers. New 2-page Bulletin 134 provides information and prices on "self-sticking" wire markers.—W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.

Circle 589 on inquiry card.

Pressure Filters. New 4-page Bulletin 6322 describes operation, control, filter bed materials, design features, available accessories, etc. of makers horizontal pressure filters, Type "D", for water use.—Cochrane Corp., 17th St. & Allegheny Ave., Phila. 32, Pa.

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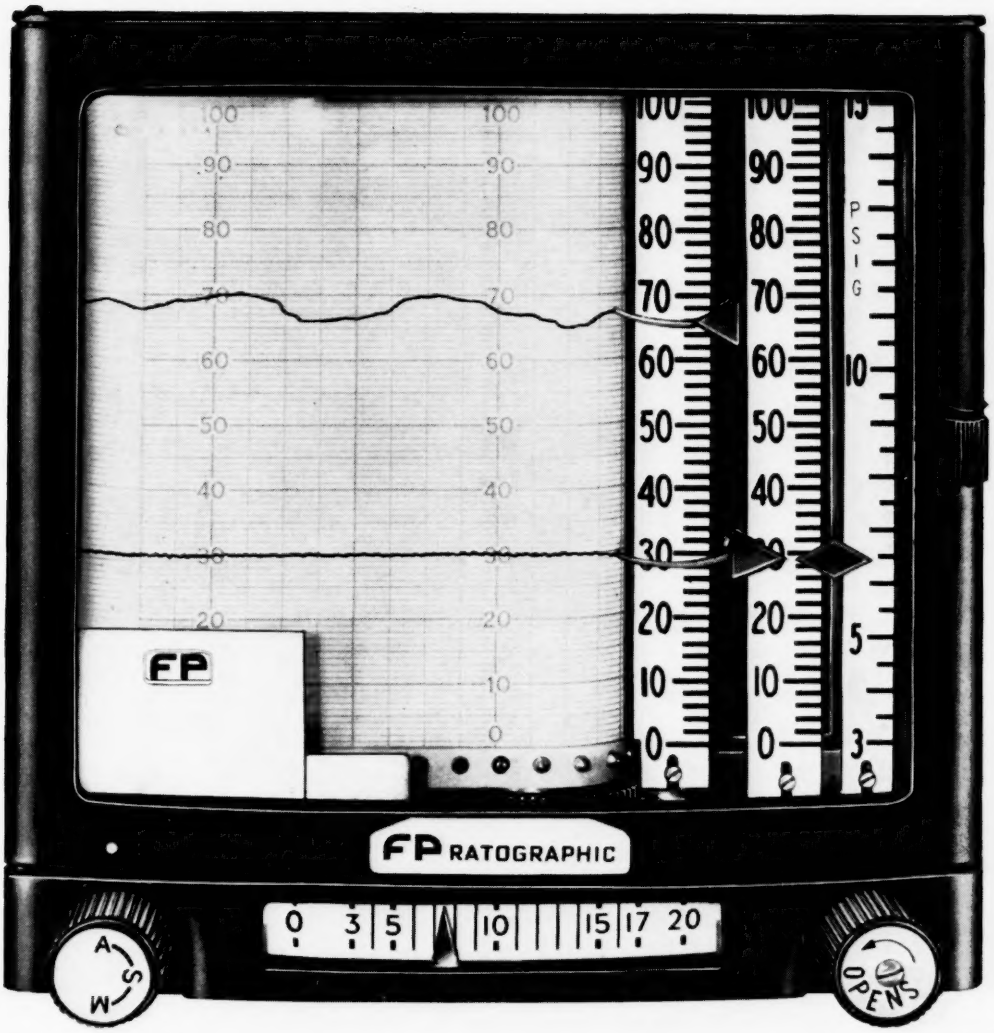

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